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(54) Title: DEVICE FOR HOLDING A PLANAR WORKPIECE AND SYSTEM AND METHOD FOR CONVEYING PLANAR WORKPIECES THROUGH A BATH OF AN APPARATUS FOR WET-CHEMICAL TREATMENT

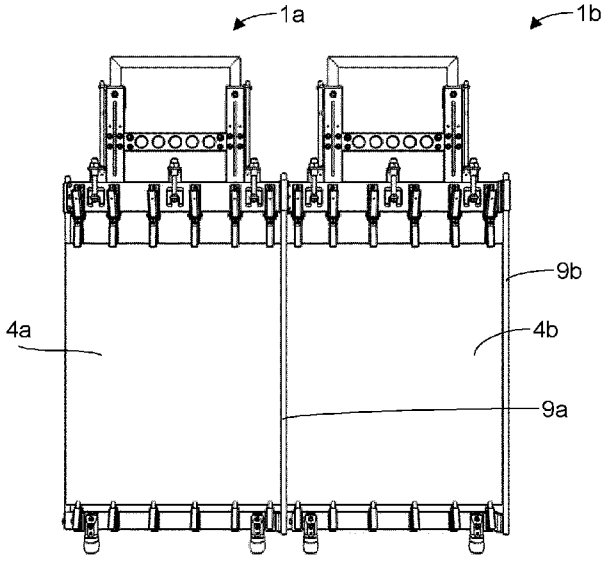


Fig. 4

(57) Abstract: A system for conveying planar workpieces (4;32) through a bath of an apparatus for wet-chemical treatment of the workpieces (4;32) comprises a plurality of workpiece holding devices (1;29). Each workpiece holding device (1;29) comprises at least one clamping device (2,3;30,31) for holding the workpiece (4;32) in a plane and a structure surrounding on at least three sides, seen perpendicular to the plane and in the absence of the workpiece, a region (8) of the plane. The structure comprises a first member (9;34) and a second member (10;35), arranged on first and second sides of the region (8) and having respective longitudinal axes extending in a first direction (z) parallel to the plane. The system further comprises a conveyor for transporting the workpiece holding devices (1;29) in a second direction (x) parallel to the plane and transverse to the first direction (z). The longitudinal axis of a leading one of

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the first and second members (9,10;34,35) of a first of the workpiece holding devices (1;29), seen in the second direction (x), and the longitudinal axis of a trailing one of the first and second members (9,10) of a next one of the workpiece holding device (1;29) in the second direction (x) are offset with respect to the respective planes of these workpiece holding devices (1;29) in opposite directions perpendicular to the planes such that the leading member (9,10;34,35) of the first workpiece holding device (1;29) and the trailing member (9,10) of the next workpiece holding device (1;29) at least partially face each other.

Device for holding a planar workpiece and system and method for conveying planar workpieces through a bath of an apparatus for wet-chemical treatment

Technical Field

The invention relates to a device for holding a planar workpiece in a bath of an apparatus for wet-chemical treatment of the workpiece, the device comprising:

at least one clamping device for holding the workpiece in a plane;

a structure surrounding on at least three sides, seen perpendicular to the plane and in the absence of the workpiece, a region of the plane,

wherein the structure comprises a first member and a second member, arranged on first and second sides of the region and having respective longitudinal axes extending in a first direction parallel to the plane, and

wherein the structure comprises an interconnecting part interconnecting the first and second members on a third side of the region; and

at least one part for attachment of the interconnecting part to a conveyor for transporting the device in a second direction parallel to the plane and transverse to the first direction.

The invention also relates to a system for conveying planar workpieces through a bath of an apparatus for wet-chemical treatment of the workpieces,

wherein the system comprises a plurality of workpiece holding devices, each workpiece holding device comprising:

at least one clamping device for holding the workpiece in a plane; and

a structure surrounding on at least three sides, seen perpendicular to the plane and in the absence of the workpiece, a region of the plane,

wherein the structure comprises a first member and a second member, arranged on first and second sides of the region and having respective longitudinal axes extending in a first direction parallel to the plane, and

wherein the system further comprises a conveyor for transporting the workpiece holding devices in a second direction parallel to the plane and transverse to the first direction.

The invention also relates to an apparatus for wet-chemical treatment of planar workpieces.

The invention also relates to a method of conveying planar workpieces through a bath of an apparatus for wet-chemical treatment of the workpieces,

wherein the workpieces are mounted in respective workpiece holding devices, each workpiece holding device comprising:

at least one clamping device for holding the workpiece in a plane; and

a structure surrounding on at least three sides, seen perpendicular to the plane and in the absence of the workpiece, a region of the plane,

wherein the structure comprises a first member and a second member, arranged on first and second sides of the region and having respective longitudinal axes extending in a first direction parallel to the plane,

wherein the workpiece holding devices are conveyed in a second direction parallel to the plane and transverse to the first direction, such that a trailing edge of a first workpiece is separated from a leading edge of a second workpiece by a gap.

Background Art

CN 209428629 U discloses a frame-shaped bracket for an electroplating machine, particularly suitable for a carrier substrate (Printed Circuit Board) that passes through a plating machine for processing purposes. The bracket includes a bar that is horizontal, in use, an opposite bar that is parallel to the bar, a right rod that is vertical in use (and thus perpendicular to the bar and bottom bar) and a left rod opposite the right rod and parallel to the right rod. The top bar, the bottom bar, the left rod and the right rod are connected to each other by two top connectors and to bottom connectors to form a rectangular frame-like structure. A plurality of top clamps are mounted on the top bar for releasably gripping the top edge of the workpiece. A plurality of bottom clamps are mounted on the bottom bar for releasably gripping the bottom edge of the workpiece. One of the top connectors is fixedly engaged (e.g. by welding) at or near the upper longitudinal end of the left rod. Similarly, the other of the top connectors is fixedly engaged at or near the upper longitudinal end of the right rod. Each top connector has a rectangular recess or groove for receiving a respective longitudinal end of the top bar. The bottom connectors are covered with an electrically insulating material. Both the left rod and the right rod are cylindrical and electrically conductive. Since the right and left rods are electrically conductive, electroplating will occur on the right and left rods. This will reduce the amount of metal plated on the left and right edges of

the workpiece and thus achieve better plating uniformity. Compared with a vertical rod having a rectangular cross-section, the cylindrical left and right rods do not induce localised current during plating. The left and right rods are shown adjacent the left and right edges of the workpiece, but not exactly in the plane of the workpiece. The effects obtained by the rods are thus not the same for the two surfaces of the workpiece. Furthermore, treatment uniformity is only obtained in electrochemical treatment, the rods must be deplated or replaced and the positions of the rods necessitate some spacing between successive workpieces mounted in brackets that are conveyed through the plating bath.

Summary of Invention

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 for surface treatment of workpieces conveyed in close succession such that relatively uniform surface treatment is achieved at the leading and trailing edges of the workpieces on both sides of the workpieces.

The object is achieved according to a first aspect by the device according to the invention, which is characterised in that the longitudinal axes are offset with respect to the plane in opposite directions perpendicular to the plane.

Because the longitudinal axes are offset with respect to the plane in opposite directions perpendicular to the plane, two holding devices can be conveyed in close succession in the second direction, with only a small (empty) gap between the leading edge of the workpiece held by the upstream device and the trailing edge of the workpiece held by the downstream device. A leading one of the first and second members of the upstream holding device faces a trailing one of the first and second members of the downstream holding device across the gap. This gives rise to a shielding effect, in that the liquid in the bath cannot flow through the gap in large quantities. Thus, excess treatment, e.g. material deposition or removal at regions of the major surfaces of the workpieces close to the edges is avoided. In case the liquid is an electrolyte and the treatment is an electrochemical treatment, less conductive liquid is present near the edge regions. The electric field lines are thus deflected from the edge regions.

The offset distances may be selected to optimise uniformity. They could be adjustable in an embodiment.

The device includes at least one clamping device for holding the workpiece in a plane. There will generally be more than one clamping device. They may be arranged along one or more edges of the region. Through their configuration and location, the clamping devices define the plane, the location and orientation of which can therefore be determined even in the absence of the workpiece. The clamping devices will generally be arranged to grip the workpiece at one or more edges of the workpiece, such that arms of the clamps of the clamping devices engage the major surfaces of the workpiece close to one or more edges of the workpiece. In the case of a quadrilateral workpiece, the clamping devices may be arranged to engage the workpiece along only one or two edges of the workpiece. This may comprise the edge proximal to the interconnecting part, and optionally an opposite edge, for example.

A structure comprised in the device surrounds on at least three sides, seen perpendicular to the plane, a region of the plane. The region will generally not correspond exactly to the complete region of the plane occupied by the workpiece. Looking onto the plane in a direction perpendicular to the plane, in the absence of the workpiece, the structure appears to surround the region on at least three sides. Note, however, that the structure will generally not lie in the plane. In particular the first and second members are offset with respect to the plane, such that they may, and generally will, not cross the plane.

The structure comprises a first member and a second member, arranged on first and second sides of the region and having respective longitudinal axes extending in a first direction parallel to the plane. Here, first and second sides refer to the appearance on the observer when looking onto the plane in a direction perpendicular to the plane and in the absence of the workpiece. In the presence of the workpiece, only one of the first and second members will generally be visible completely, because the other will lie at least partially behind the workpiece. The first and second members will generally be of corresponding shape and dimension to achieve better uniformity of the flow field past both surfaces of the workpiece.

The structure comprises an interconnecting part interconnecting the first and second members on a third side of the region. This interconnecting part need not be a single element, but may be an assembly. The interconnecting part is attachable to a conveyor by at least one part for attachment of the interconnecting part to the conveyor. This attachment part may be a hook or arm. Thus, in use, the interconnecting part interconnecting the first and second members on a third side of the region will generally be an upper interconnecting part. The third side will be the side higher than the region. The device could be considered a hanger for the workpiece.

At least one part is provided for attachment of the interconnecting part to a conveyor for transporting the device in a second direction parallel to the plane and transverse to the first direction. The conveyor may comprise a chain or belt, for example, or a shuttle on a guide rail or track. The direction of movement is thus such that one of the first and second members is at a leading edge of the workpiece and the other is at a trailing edge of the workpiece. Because the longitudinal axes are offset with respect to the plane in opposite directions perpendicular to the plane, as opposed to being offset in the same direction, the workpiece can be mounted and unloaded from one side with only one of the first and second members in the way. This can involve moving the workpiece along a trajectory comprising a pivot about an axis parallel to the longitudinal axes of the first and second members. It is also possible to obtain the shielding effect due to the leading one of the first and second members of an upstream holding device facing a trailing one of the first and second members of the downstream holding device across a gap between the workpiece edges by providing holding devices in which the longitudinal axes of the first and second members are offset in the same direction. In that case, every other device would be turned to face in an opposite direction to the adjacent holding devices. However, every other holding device would then have both the first and second members in the way of the workpiece to be unloaded or mounted. The workpieces could therefore not be mounted or unloaded from the same side of each device. By contrast, here, at least a section between any points of attachment to parts interconnecting the first and second members of each of the first and second members faces into an empty space in the direction of the plane. This empty space is available for manoeuvring the workpiece.

In an embodiment, the interconnecting part is releasably connected to at least one of the first and second members by a respective fixing device, and a location of engagement between the fixing device and the one of the first and second members concerned is variable in the first direction.

This provides a simple way of adjusting the structure to workpieces of varying dimensions in the first direction. The structure can remain relatively rigid. For variability of the other dimension, the interconnecting part may be an assembly of parts of which the mutual position is adjustable to adjust the dimension of the interconnecting part that is parallel to the second direction.

In an embodiment, at least one of the at least one clamping devices is supported by the interconnecting part.

The interconnecting part is for attachment to the conveyor. Thus, the load of the workpiece will be transmitted via the clamping devices and the interconnecting part to the conveyor. The first and second members need be load-bearing to only a limited extent. Moreover, the shielding effect is not disrupted by clamping devices in embodiments in which clamping devices are only provided on one or both other sides of the region than the one on which, seen in the direction perpendicular to the plane, the first and second members are arranged. Limiting the number of sides on which the clamping devices are provided also simplifies the mounting and unloading of workpieces to and from the device.

In an embodiment, the interconnecting part comprises a third member, extending in the second direction, and the first and second members are connected to the third member at opposite ends of the third member.

In this embodiment, the structure is relatively simple and strong. The third member need not, and generally will not, be rod-shaped.

In an example of the embodiment in which at least one of the at least one clamping devices is supported by the interconnecting part, the interconnecting part comprises a third member, extending in the second direction, and the first and second members are connected to the third member at opposite ends of

the third member, the clamping devices supported by the interconnecting part are supported by the third member.

This further simplifies the interconnecting part.

In an example of any embodiment in which at least one of the at least one clamping devices is supported by the interconnecting part, the clamping devices supported by the interconnecting part are journalled for movement in the first direction relative to the interconnecting part, and the device comprises at least one biasing device for biasing the clamping devices journalled for movement away from the region in the first direction.

An effect is that mounting and unloading of the workpiece is simplified, since the clamping devices can be moved in a non-clamping configuration in the direction of the region past an edge of the workpiece, grip the workpiece and then be released. To unload, the grip is released and the clamping devices automatically move out of the way. In embodiments in which the workpiece is gripped by clamping devices at opposite edges, relatively flexible workpieces can be held under tension to maintain their surfaces in a flat state and thus provide a more uniform surface treatment.

In an example of any embodiment in which at least one of the at least one clamping devices is supported by the interconnecting part, the clamping devices supported by the interconnecting part are journalled for movement in the first direction relative to the interconnecting part, and the device comprises at least one biasing device for biasing the clamping devices journalled for movement away from the region in the first direction, a plurality of clamping devices are mounted to a single common support member journalled for movement in the first direction relative to the interconnecting part, and the at least one biasing devices act on the common support member.

This makes it easier to move all of the clamping devices supported by the interconnecting part together and to provide for uniform tensioning of the workpiece. Furthermore, there can be relatively many clamping devices and only few biasing devices, saving on parts. The biasing devices may be pre-tensioned. In that case, the level of pre-tension may be adjustable. The biasing

devices may comprise any type of elastic device (helical spring, leaf spring, elastomer structures, etc.) or a gas spring, for example.

In an embodiment of the device, the structure comprises a further interconnecting part interconnecting the first and second members and located on a fourth side of the region.

This makes the structure more rigid and facilitates keeping the first and second member in the correct position with the correct orientation. Furthermore, the further interconnecting part can serve to support other parts of the device, such as one or more of the clamping devices. Generally, the fourth side will be the side lower than the region, so that the further interconnecting part is a lower interconnecting part compared with the interconnecting part on the third (opposite) side of the region, which is an upper interconnecting part.

In an example of any embodiment in which the structure comprises a further interconnecting part interconnecting the first and second members and located on a fourth side of the region, the further interconnecting part is releasably connected to at least one of the first and second members by a respective fixing device, and a location of engagement between the fixing device and the one of the first and second members concerned is variable in the first direction.

In this embodiment, the dimension of the device parallel to the first direction can be adjusted. This may be required to adapt the device to a different type of bath, a different conveyor positon, or a workpiece with a differently-sized corresponding dimension.

In an example of any embodiment in which the structure comprises a further interconnecting part interconnecting the first and second members and located on a fourth side of the region, the further interconnecting part comprises a further member, extending in the second direction, and the first and second members are connected to the further member at opposite ends of the further member.

This makes the further interconnecting part simpler. The device is, amongst others, easier to manoeuvre, because the fourth side is generally the lower

side, and thus submerged in the bath near the bottom thereof. A straight member poses less risk of collision or of being caught on parts arranged at the bottom of the bath.

In an example of any embodiment in which the structure comprises a further interconnecting part interconnecting the first and second members and located on a fourth side of the region, the further interconnecting part is provided with at least one follower part for engaging a guide defining a path through the bath in the second direction.

In particular in apparatus for electrochemical surface treatment of the workpiece, the guide aids the conveyor in keeping the workpiece surfaces at a defined distance to electrodes arranged in the bath of the apparatus. Furthermore, the conveyor and the part for attachment of the interconnecting part to the conveyor can be of a lighter construction without increased risk of swinging of the device and workpiece.

In an example of any embodiment in which the structure comprises a further interconnecting part interconnecting the first and second members and located on a fourth side of the region, at least one of the clamping devices is supported by the further interconnecting part.

This helps restrain movement, in particular swinging movement, of the workpiece relative to the device. Furthermore, the workpiece can be tensioned in the first direction. This allows the device to hold relatively thin and flexible workpieces, e.g. foils.

In an embodiment of the device, the first and second members are rod-shaped along at least a majority of their respective lengths.

In this embodiment, it is relatively easy to manoeuvre the workpiece relative to the device when mounting and unloading the workpiece. There is a low risk of the workpiece hitting the first or second member. Furthermore, the shielding effect provided by the first and second members is relatively uniform in the first direction. The majority may comprise a central longitudinal section, so that only end sections deviate from the rod-shape, e.g. because fixing devices

or structures for engaging such devices are provided at the longitudinal ends of the first and second members.

In an example of any embodiment in which the first and second members are rod-shaped along at least a majority of their respective lengths, the first and second members are circle-cylindrically-shaped along at least a majority of their respective lengths.

This helps improve the uniformity of the shielding effect, because the flow of liquid past the first and second members is relatively smooth. There will be few or no vortices. Furthermore, should the workpiece unintentionally hit the first or second member during mounting or unloading, the risk of severe damage is reduced.

In an embodiment of the device, at least a surface of the first and second members is formed by electrically insulating material along at least a majority of their respective lengths.

This makes the device particularly suited for use in conjunction with apparatus for electrochemical treatment, e.g. plating or etching. The first and second members are not plated or weakened. They provide only the shielding effect that enhances the uniformity of treatment of the workpiece surface at the edge regions. The first and second members may be made in one piece out of electrically insulating material (e.g. extruded or moulded), co-moulded with an outer layer of electrically insulating material or provided with a sheath of such material.

In an embodiment of the device, at least one of the first and second members is the only part of the structure extending from the interconnecting part in the first direction over the distance over which that member extends on the side of the region on which that member is provided.

This ensures that the shielding effect between two successive devices is provided on one side of the gap between the workpiece edges by only one of the first and second members of one of the devices and on the other side of the gap by only one of the first and second members of the adjacent device.

Structures that could disturb the flow of liquid or, in apparatus for electrochemical treatment, the electrical field, in an unpredictable manner are avoided. Furthermore, manoeuvring of the workpiece relative to the device during mounting and unloading is simplified. In particular, relative movements including pivots of the workpiece about an axis parallel to the longitudinal axes of the first and second members whilst the workpiece is in a position between the first and second members and crossing the plane are made possible. Here, the term 'side' again refers to the perspective of an observer looking onto the region in a direction perpendicular to the plane in which the clamping devices are arranged to hold the workpiece.

In an embodiment of the device, the part for attachment of the interconnecting part to a conveyor is configured for attachment of the interconnecting part to an overhead conveyor to suspend the device from the overhead conveyor.

Thus, the device need not comprise components for transporting the device through the bath at positions likely to be submerged in the liquid of the bath of the apparatus for wet-chemical treatment. Lifting and lowering may be achieved by varying the level at which the conveyor is arranged, rather than by including the requisite components in the device.

According to another aspect, the system according to the invention for conveying planar workpieces is characterised in that the longitudinal axis of a leading one of the first and second members of a first of the workpiece holding devices, seen in the second direction, and the longitudinal axis of a trailing one of the first and second members of a next one of the workpiece holding devices in the second direction are offset with respect to the respective planes of these workpiece holding devices in opposite directions perpendicular to the planes such that the leading member of the first workpiece holding device and the trailing member of the next workpiece holding device at least partially face each other.

In an embodiment of the system, the workpiece holding devices are devices according to the invention. However, in another embodiment of the system, in each workpiece holding device, the first and second members are provided on the same side of the plane.

Thus, the system provides the same shielding effect of the edge regions of the workpieces that follow on each other in the second direction. The leading one of the first and second members of the first workpiece holding device and the trailing one of the first and second members of the next workpiece holding device at least partially face each other across the gap between the leading edge of the workpiece held by the first workpiece holding device and the trailing edge of the workpiece held by the second workpiece holding device. The first and second members will generally be of corresponding shape and dimension to achieve good uniformity of the flow field past both surfaces of the workpiece.

In an embodiment of the system in which, in each workpiece holding device, the first and second members are provided on the same side of the plane, in each workpiece holding device, the structure comprises an interconnecting part interconnecting the first and second members on a third side of the region, the interconnecting part is releasably connected to at least one of the first and second members by a respective fixing device, and a location of engagement between the fixing device and the one of the first and second members concerned is variable in the first direction.

This provides a simple way of adjusting the structure to workpieces of varying dimensions in the first direction. The structure can remain relatively rigid. For variability of the other dimension, the interconnecting part may be an assembly of parts of which the mutual position is adjustable to adjust the dimension of the interconnecting part that is parallel to the second direction.

For variability of the other dimension, the interconnecting part may be an assembly of parts of which the mutual position is adjustable to adjust the dimension of the interconnecting part that is parallel to the second direction.

In an example of any embodiment of the system in which, in each workpiece holding device, the first and second members are provided on the same side of the plane, in each workpiece holding device, the structure comprises an interconnecting part interconnecting the first and second members on a third side of the region, and at least one of the at least one clamping devices is supported by the interconnecting part.

The interconnecting part is for attachment to the conveyor. Thus, the load of the workpiece will be transmitted via the clamping devices and the interconnecting part to the conveyor. The first and second members need be load-bearing to only a limited extent. Moreover, the shielding effect is not disrupted by clamping devices in embodiments in which clamping devices are only provided on one or both other sides of the region than the one on which, seen in the direction perpendicular to the plane, the first and second members are arranged. Limiting the number of sides on which the clamping devices are provided also simplifies the mounting and unloading of workpieces to and from the device.

In example of any embodiment of the system in which, in each workpiece holding device, the first and second members are provided on the same side of the plane, in each workpiece holding device, the structure comprises a third member interconnecting the first and second members on a third side of the region, and the first and second members are connected to the third member at opposite ends of the third member.

In this embodiment, the structure is relatively simple and strong. The third member need not, and generally will not, be rod-shaped.

In an example of any embodiment of the system in which, in each workpiece holding device, the first and second members are provided on the same side of the plane, the structure comprises an interconnecting part interconnecting the first and second members on a third side of the region, at least one of the at least one clamping devices is supported by the interconnecting part, the structure comprises a third member interconnecting the first and second members on a third side of the region, and the first and second members are connected to the third member at opposite ends of the third member, the clamping devices supported by the interconnecting part are supported by the third member.

This further simplifies the interconnecting part. The clamping devices need not be mounted in a fixed position relative to the third member in this embodiment.

In an example of any embodiment of the system in which, in each workpiece holding device, the first and second members are provided on the same side of

the plane, the structure comprises an interconnecting part interconnecting the first and second members on a third side of the region, and at least one of the at least one clamping devices is supported by the interconnecting part, the clamping devices supported by the interconnecting part are journalled for movement in the first direction relative to the interconnecting part, and the workpiece holding device comprises at least one biasing device for biasing the clamping devices journalled for movement away from the region in the first direction.

An effect is that mounting and unloading of the workpiece is simplified, since the clamping devices can be moved in a non-clamping configuration in the direction of the region past an edge of the workpiece, grip the workpiece and then be released. To unload, the grip is released and the clamping devices automatically move out of the way. In embodiments in which the workpiece is gripped by clamping devices at opposite edges, relatively flexible workpieces can be held under tension to maintain their surfaces in a flat state and thus provide a more uniform surface treatment.

In an example of any embodiment of the system in which, in each workpiece holding device, the first and second members are provided on the same side of the plane, the structure comprises an interconnecting part interconnecting the first and second members on a third side of the region, at least one of the at least one clamping devices is supported by the interconnecting part, the clamping devices supported by the interconnecting part are journalled for movement in the first direction relative to the interconnecting part, and the workpiece holding device comprises at least one biasing device for biasing the clamping devices journalled for movement away from the region in the first direction, a plurality of clamping devices are mounted to a single common support member journalled for movement in the first direction relative to the interconnecting part, and the at least one biasing devices act on the common support member.

This makes it easier to move all of the clamping devices supported by the interconnecting part together and to provide for uniform tensioning of the workpiece. Furthermore, there can be relatively many clamping devices and only few biasing devices, saving on parts. The biasing devices may be pre-tensioned. In that case, the level of pre-tension may be adjustable. The biasing

devices may comprise any type of elastic device (helical spring, leaf spring, elastomer structures, etc.) or a gas spring, for example.

In an example of any embodiment of the system in which, in each workpiece holding device, the first and second members are provided on the same side of the plane, in each workpiece holding device, the structure comprises a first interconnecting part interconnecting the first and second members on a third side of the region, and a further interconnecting part interconnecting the first and second members on a fourth side of the region.

This makes the structure more rigid and facilitates keeping the first and second member in the correct position with the correct orientation. Furthermore, the further interconnecting part can serve to support other parts of the device, such as one or more of the clamping devices.

In an example of any embodiment of the system in which, in each workpiece holding device, the first and second members are provided on the same side of the plane, the structure comprises a first interconnecting part interconnecting the first and second members on a third side of the region, and a further interconnecting part interconnecting the first and second members on a fourth side of the region, the further interconnecting part is releasably connected to at least one of the first and second members by a respective fixing device, and a location of engagement between the fixing device and the one of the first and second members concerned is variable in the first direction.

In this embodiment, the dimension of the workpiece holding devices parallel to the first direction can be adjusted. This may be required to adapt the workpiece holding devices to a different type of bath, a different conveyor positon, or a workpiece with a differently-sized corresponding dimension.

In an example of any embodiment of the system in which, in each workpiece holding device, the first and second members are provided on the same side of the plane, the structure comprises a first interconnecting part interconnecting the first and second members on a third side of the region and a further interconnecting part interconnecting the first and second members on a fourth side

of the region, the further interconnecting part comprises a further member, extending in the second direction, and the first and second members are connected to the further member at opposite ends of the further member.

This makes the further interconnecting part simpler. The workpiece holding devices are, amongst others, easier to manoeuvre, because the fourth side is generally the lower side, and thus submerged in the bath near the bottom thereof. A straight member poses less risk of collision or of being caught on parts arranged at the bottom of the bath.

In an example of any embodiment of the system in which, in each workpiece holding device, the first and second members are provided on the same side of the plane, the structure comprises a first interconnecting part interconnecting the first and second members on a third side of the region, and a further interconnecting part interconnecting the first and second members on a fourth side of the region, the further interconnecting part is provided with at least one follower part for engaging a guide defining a path through the bath in the second direction.

In particular in apparatus for electrochemical surface treatment of the workpiece, the guide aids the conveyor in keeping the workpiece surfaces at a defined distance to electrodes arranged in the bath of the apparatus. Furthermore, the conveyor and the part for attachment of the interconnecting part to the conveyor can be of a lighter construction without increased risk of swinging of the workpiece holding devices and workpiece.

In an example of any embodiment of the system in which, in each workpiece holding device, the first and second members are provided on the same side of the plane, the structure comprises a first interconnecting part interconnecting the first and second members on a third side of the region, and a further interconnecting part interconnecting the first and second members on a fourth side of the region, at least one of the clamping devices is supported by the further interconnecting part.

This helps restrain movement, in particular swinging movement, of the workpiece relative to the workpiece holding device. Furthermore, the workpiece

can be tensioned in the first direction. This allows the workpiece holding devices to hold relatively thin and flexible workpieces, e.g. foils.

In an embodiment of the system, in which, in each workpiece holding device, the first and second members are provided on the same side of the plane ,in each workpiece holding device, the first and second members are rod-shaped along at least a majority of their respective lengths.

In this embodiment, it is relatively easy to manoeuvre the workpiece relative to the workpiece holding device when mounting and unloading the workpiece. There is a low risk of the workpiece hitting the first or second member. Furthermore, the shielding effect provided by the first and second members is relatively uniform in the first direction. The majority may comprise a central longitudinal section, so that only end sections deviate from the rod-shape, e.g. because fixing devices or structures for engaging such devices are provided at the longitudinal ends of the first and second members.

In an example of any embodiment of the system in which, in each workpiece holding device, the first and second members are provided on the same side of the plane and the first and second members are rod-shaped along at least a majority of their respective lengths, the first and second members are circle-cylindrically-shaped along at least a majority of their respective lengths.

This helps improve the uniformity of the shielding effect, because the flow of liquid past the first and second members is relatively smooth. There will be few or no vortices. Furthermore, should the workpiece unintentionally hit the first or second member during mounting or unloading, the risk of severe damage is reduced.

In an embodiment of the system in which, in each workpiece holding device, the first and second members are provided on the same side of the plane, in each workpiece holding device, at least a surface of the first and second members is formed by electrically insulating material along at least a majority of their respective lengths.

This makes the system particularly suited for use in conjunction with apparatus for electrochemical treatment, e.g. plating or etching. The first and second

members are not plated or weakened. They provide only the shielding effect that enhances the uniformity of treatment of the workpiece surface at the edge regions. The first and second members may be made in one piece out of electrically insulating material (e.g. extruded or moulded), co-moulded with an outer layer of electrically insulating material or provided with a sheath of such material.

In an embodiment of the system, in which, in each workpiece holding device, the first and second members are provided on the same side of the plane, in each workpiece holding device, at least one of the first and second members is the only part of the structure extending from the interconnecting part in the first direction over the distance over which that member extends on the side of the region on which that member is provided.

This ensures that the shielding effect between two successive workpiece holding devices is provided on one side of the gap between the workpiece edges by only one of the first and second members of one of the workpiece holding devices and on the other side of the gap by only one of the first and second members of the adjacent workpiece holding device. Structures that could disturb the flow of liquid or, in apparatus for electrochemical treatment, the electrical field, in an unpredictable manner are avoided. Furthermore, manoeuvring of the workpiece relative to the workpiece holding device during mounting and unloading is simplified. In particular, relative movements including pivots of the workpiece about an axis parallel to the longitudinal axes of the first and second members whilst the workpiece is in a position between the first and second members and crossing the plane are made possible. Here, the term ‘side’ again refers to the perspective of an observer looking onto the region in a direction perpendicular to the plane in which the clamping devices are arranged to hold the workpiece.

An embodiment of the system further comprises at least one of a loading device for mounting a workpiece to one of the workpiece holding devices and an unloading device for removing a workpiece from one of the workpiece holding devices, the loading device comprising a manipulator for moving the workpiece and being configured to move the workpiece into a position in the plane in which the first and second members are in at least partial overlap with edge regions of the workpiece, seen in a direction perpendicular to the plane, the

unloading device comprising a manipulator for moving the workpiece and being configured to move the workpiece out of the position in the plane in which the first and second members are in at least partial overlap with edge regions of the workpiece, seen in a direction perpendicular to the plane, wherein the movement comprises a pivoting component about a pivot axis parallel to the longitudinal axes of the first and second members.

In particular in embodiments in which the workpiece holding devices are devices according to the invention, in which at least the longitudinal axes of the first and second members are offset in opposite direction with respect to the plane, the workpieces can be mounted to and/or unloaded from the workpiece holding devices from one side without removing the workpiece holding devices from the conveyor. The pivoting movement allows the workpiece to be moved around those of the first and second members that might otherwise be in the way. It is noted that the mounting device and the unloading device may be one and the same device.

In embodiment of the system, the conveyor is an overhead conveyor and the workpiece holding devices are suspended from the overhead conveyor.

In this embodiment, it is relatively easy to ensure that the liquid flow field is similar on both sides of the workpiece, because the workpiece is oriented vertically. Gravitational effects on the flow field are equal for both sides. Furthermore, no part of the conveyor need be submerged in the liquid in the bath of the apparatus for wet-chemical treatment.

According to another aspect, the apparatus for wet-chemical treatment of planar workpieces according to the invention comprises at least one system according to the invention.

Wet-chemical treatment may include rinsing, electroless plating, pickling and the like. The treatment may in particular comprise electrochemical treatment. In that case, the apparatus will include one or more electrodes arranged in the bath and at least one device for establishing a potential difference between one or both surfaces of the workpiece and the electrode(s). At least one of the clamping devices of each workpiece holding device will then be arranged to

contact the surface of the workpiece electrically and configured for electrical connection to the device for establishing the potential difference.

According to another aspect, the method according to the invention of conveying planar workpieces through a bath of an apparatus for wet-chemical treatment of the workpieces is characterised in that one of the first and second members of the workpiece holding device in which the first workpiece is mounted and one of the first and second members of the workpiece holding device in which the second workpiece is mounted face each other across the gap.

The method may comprise the use of a system according to the invention. Equally, the device and system according to the invention may be suitable and/or configured to carry out the method according to the invention.

Brief Description of Drawings

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

Fig. 1	is a cross-sectional view through an electroplating tank in an apparatus for wet-chemical treatment of planar workpieces;
Fig. 2	is a front view of a first workpiece holding device for holding a planar workpiece in a bath in the apparatus;
Fig.3	is a side view of the workpiece holding device shown in Fig. 2;
Fig. 4	is a front view of a pair of workpiece holding devices as shown in Figs. 2 and 3;
Fig. 5	is a detailed top view of adjacent end regions of the pair of workpiece holding devices of Fig. 4;
Fig. 6	is a perspective view of an, in use, lower region of the workpiece holding device of Figs. 2-5 without the workpiece;
Fig. 7	is a first perspective view of an, in use, upper region of the workpiece holding device of Fig. 6 without the workpiece;
Fig. 8	is a second perspective view of the upper region of the workpiece holding device of Figs. 6 and 7 without the workpiece;
Fig. 9	is a view corresponding to that of Fig. 8, but with a support member to which clamping devices are fixed removed;
Fig. 10	is a front view of a second workpiece holding device;

Fig. 11 is a perspective view of a lower region of the workpiece holding device of Fig. 10;

Fig. 12 is a side view of an upper region of the workpiece holding device of Figs. 10 and 11;

Fig. 13 is a first perspective view of the upper region of the workpiece holding device of Figs. 10-12;

Fig. 14 is a second perspective view of the upper region of the workpiece holding device of Figs. 10-13; and

Figs. 15A, B are schematic diagrams illustrating the principle underlying conveying systems comprising the first and second workpiece holding devices, respectively.

Description of Embodiments

In the following, two types of system for conveying planar workpieces through a bath or baths of an apparatus for wet-chemical treatment of the workpieces will be described. The apparatus may be configured for electrochemical treatment of the workpieces, e.g. electroplating or etching, in particular, but the system is not limited to use in such types of apparatus. The apparatus may also or alternatively be configured to carry out stripping, washing, degreasing and the like.

Both systems comprise a plurality of workpiece holding devices, also referred to as jigs, and a conveyor to which the workpiece holding devices are connected. The conveyor is an overhead conveyor and the workpiece holding devices are suspended from the conveyor, such that at least a lower region of the workpiece holding device as well as the workpiece can be submerged in the apparatus bath or baths. The workpiece is conveyed through the bath in a substantially upright orientation, moving in a direction parallel to the plane of the workpiece. At least whilst being conveyed through the bath or baths, the workpiece holding devices and workpieces are arranged close together in the direction of movement, with the trailing edge of one of the workpieces only slightly ahead of the leading edge of the next one of the workpieces. The gap between the leading and trailing edge is shielded to one side by (only) one of the two workpiece holding devices and to the other side by (only) the other of the two workpiece holding devices. The gap is left unobstructed by the workpiece holding devices, so that the edges can be close together. The shielding

limits the amount of (fresh) processing liquid flowing past the workpieces in the region adjacent the edges. In the first system, the workpiece holding devices are all the same, but the arrangement of members that effect the shielding is asymmetric with respect to a plane in which the workpiece lies and a plane transverse thereto. The members are offset in opposite directions with respect to the plane in which the workpiece lies. In the second system, the arrangement of shielding members is the same for each workpiece holding device, but the side on which the shielding members lie faces alternately in opposite directions, in use.

A workpiece holding device 1 for the first system (Figs. 2-9, 15A) comprises a plurality of upper clamping devices 2a-f (Figs. 7-9) and a plurality of lower clamping devices 3a-f (Fig. 6) for holding a planar workpiece 4. In the illustrated embodiment, there are equal numbers of upper clamping devices 2a-f and lower clamping devices 3a-f. In alternative embodiments, their number may differ. In particular, there may be fewer lower clamping devices 3a-f. If the workpiece 4 is relatively stiff or has a relatively large mass, the lower clamping devices 3a-f might even be dispensed with.

In the illustrated embodiment, at least some of the clamping devices 2a-f,3a-f are arranged electrically to contact at least one, e.g. both, major surfaces of the workpiece 4. If the treatment of the workpiece is to include electroplating, the treatment apparatus will be configured to apply a potential difference causing the surface or surfaces of the workpiece 4 to function as a cathode. Anodes 5a,b (Fig. 1) are arranged in a tank 6 of the apparatus. Spray bars 7a,b are arranged in the tank 6 to flood the workpiece 4 with electrolyte solution.

In a typical electroplating apparatus, the surfaces of the workpiece 4 will be pre-coated with a (thin) layer of conducting material, e.g. by means of vapour deposition or the like. Thus, the workpiece 4 will already enter the tank 6 with the surfaces thereof in an electrically conducting state. For this reason, only the upper clamping devices 2 may be arranged electrically to contact one or both major surfaces of the workpiece 4 in an embodiment. In such an embodiment, the lower clamping devices 3a-f merely hold the workpiece 4.

Through their position and configuration, the clamping devices 2a-f,3a-f define the plane in which the workpiece 4 will lie when held by the workpiece holding device 1.

The workpiece holding device 1 comprises a structure surrounding on at least three sides a region 8 of the plane, seen from a direction perpendicular to the plane (Fig. 2). The region 8 does not correspond to the complete area occupied by the workpiece 4, however, because first and second members 9,10 comprised in the structure overlap with edge regions of the workpiece 4. The first and second members 9,10 are arranged on first and second, opposite, sides of the region 8, seen perpendicular to the plane. The first and second members 9,10 have respective longitudinal axes extending in a first direction *z* parallel to the plane. This direction *z* corresponds to an upright, or vertical, orientation of these longitudinal axes, in use. Movement, in use, is in a second direction *x* parallel to the plane and transverse to the first direction.

In the illustrated embodiment, the structure surrounding the region 8 on at least three sides, seen perpendicular to the plane, actually surrounds the region 8 on four sides, so that the region 8 appears to be framed. The structure comprises an upper interconnecting part 11 and a lower (also referred to as further) interconnecting part 12. The upper clamping devices 2a-f are supported by the upper interconnecting part 11. The lower clamping devices 3a-f are supported by the lower interconnecting part 12.

First and second parts 13,14 (Fig. 7) for attachment of the upper interconnecting part 11 to a conveyor are provided for attaching the upper interconnecting part 11 to an overhead conveyor for transporting the workpiece holding device 1 in the second direction *x*. The first and second parts 13,14 for attachment of the upper interconnecting part 11 to a conveyor attach the workpiece holding device 1 to the conveyor such that the workpiece holding device 1 is suspended from the conveyor. In the illustrated embodiments, the first and second parts 13,14 for attachment of the upper interconnecting part 11 to a conveyor are hooks. Other types of attachment are conceivable and the number of such parts may also be varied.

At least the longitudinal axes of the first and second members 9,10 are offset in opposite directions perpendicular to the plane. These directions are also

perpendicular to the first and second directions *z,x*. In the illustrated embodiment, the first and second members 9,10 are entirely offset with respect to the plane. They may be spaced apart from the plane by a distance equal to at least half the thickness of the workpiece 4 that the workpiece holding device 1, more specifically the clamping devices 2a-f,3a-f, are configured to hold. This may be a distance in the order of millimetres, e.g. at least 1, 2 or 5 mm.

In the illustrated embodiment, the upper interconnecting part 11 comprises a third member 15, extending in the second direction *x*. The first and second members 9,10 are connected to the third member 15 at opposite ends of the third member 15 by first and second fixing devices 16,17. In the illustrated embodiment, the first and second fixing devices 16,17 are configured for releasably connecting the first and second members 9,10 to the third member 15, respectively. The location of engagement between the fixing devices 16,17 and the first member 9 and second member 10, respectively, is variable in the first direction *z*, in this case along the lengths of the first and second members 9,10. Thus, the workpiece holding device 1 can be adapted to workpieces 4 of different dimensions within at least a certain range. In the illustrated embodiment, the first and second fixing devices 16,17 are clamps. Alternatives providing the same variability in the location of engagement are conceivable.

It would be possible to mount the upper clamping devices 2a-f directly to the third member 15 in fixed position. Instead, in the illustrated embodiment, the upper clamping devices 2a-f are mounted to a single support member 18 in a fixed position relative to the support member 18. The support member 18 is journalled for movement relative to the third member 15 in the first direction *z*. Biasing devices 19a-c bias the support member 18 and thus the upper clamping devices 2a-f away from the region 8 in the first direction *z*. In the illustrated embodiment, the biasing devices 19a-c act on the support member 18 and the third member 15. In the illustrated embodiment, the biasing devices 19a-c are helical tension springs. In other embodiments, gas springs might be used, for example. In the illustrated embodiments, the biasing devices 19a-c are pre-tensioned and the pre-tension is adjustable.

The movably journalled support member 18 facilitates the mounting of the workpiece 4 to the workpiece holding device 1. The biasing due to the biasing

devices 19a-c also contributes to this effect and stretches thin and flexible planar workpieces 4 in the first direction *z*.

The lower interconnecting part 12 comprises a fourth member 20 (Fig. 6), extending in the second direction *x*. The first and second members 9,10 are connected to the fourth member 20 at opposite ends of the fourth member 20. The first and second members 9, 10 may be welded or otherwise joined to first and second mounting blocks 21,22 (Figs. 3 and 6) provided on opposite sides of the fourth member 20 to define the offsets with respect to the plane in which the clamping devices 2,3a-f are arranged to hold the workpiece 4.

The lower clamping devices 3a-f are mounted to the fourth member 20 in fixed positions by fasteners, e.g. bolts or screws.

In other embodiments, the mounting blocks 21,22 may be replaced by fixing devices such as the first and second fixing devices 16,17. Also, the lower clamping devices 3a-f may be journalled for movement in the first direction *z* with respect to the fourth member 20 and biased in the first direction *z* away from the region 8.

In the illustrated embodiment, first and second follower parts 23,24 in the form of guide rollers are mounted to the fourth member 20 and protrude outwards from the fourth member 20 in the first direction *z*. The follower parts 23,24 interact with a guide 25 (Fig. 1) defining a path through the tank 6 in the first direction *x*. Instead of guide rollers, other types of follower parts 23,24 for engaging the guide 25 are conceivable.

The illustrated embodiment, the first and second members 9,10 are cylindrical in shape, with a circular cross-section. Other cross-sectional shapes, such as square, are conceivable. The constant cross-section over at least a section of the length at an end of the first and second member 9,10 allows for the variable point of engagement with the first and second fixing devices 16,17 used in the illustrated embodiment. A circular cross-sectional shape allows for deflections with little risk of damage, should the workpiece 4 touch the first or second member 9,10 during mounting or unloading of the workpiece 4 to or from the workpiece holding device 1. Furthermore, the flow of processing liquid

over the surface of the workpiece 4 due to movement of the workpiece holding device 1 in the second direction *x* is less turbulent.

In other embodiments, e.g. embodiments not comprising the first and second fixing devices 16,17, one or more end sections of the first and second members 9,10 may deviate in shape from that of a rod, whereas a central section forming a majority of the length of the first and second members 9,10 may be rod-shaped, e.g. circle-cylindrical in shape.

For electrochemical treatment purposes, at least a surface of the first and second members 9,10 is formed by electrically insulating material along at least a majority of their respective lengths. This includes a central section of each of the first and second member 9,10. In one embodiment, the first and second members 9,10 are made entirely of electrically insulating material. Alternatively, they may be made of metal or a metal alloy and provided with an electrically insulating sheath or coating over at least a majority of their respective lengths. In all embodiments, the first and second members 9,10 may be tubular. This saves weight. Moreover, an electrical cable may be arranged inside at least one of the first and second members 9,10. This can be useful in an embodiment in which the lower clamping devices 3a-f are configured to contact one or both major surfaces of the workpiece 4 electrically. A similar effect can be achieved if one or both of the first and second members 9,10 are provided with an electrically conducting core and an electrically insulating cladding.

In a system comprising at least two workpiece holding devices 1a,b (Fig. 4, 5, 15A), successive workpiece holding devices 1a,b are attached to the conveyor such that there is a gap between a leading edge 26 (Fig. 15A) of the workpiece 4a held by an upstream workpiece holding device 1a and a trailing edge 27b of a workpiece 4b held by a downstream workpiece holding device 1b. A first member 9a of the upstream workpiece holding device 1a faces a second member 10b of the downstream workpiece holding device 1b across the gap. This is because the first member 9a and the second member 10b are offset in opposite directions perpendicular to the planes in which the workpiece holding devices 1a,b are arranged to hold the respective workpieces 4a,b. The distances by which first member 9a and the second member 10b are offset with respect to the respective planes are at least approximately equal in the illustrated embodiment.

When a potential difference is applied between the anodes 5a,b and the workpieces 4a,b, the first member 9a and second member 10b facing each other across the gap between the leading edge 26a and the trailing edge 27b provide a shielding effect. Electric field lines 28a,b are deflected from edge regions of the workpieces 4a,b. The offset distance to the plane in which the workpieces 4a,b are held can be optimised for surface uniformity at the edges 26a,27b.

To mount and unload the workpieces 4 to and from the respective workpiece holding devices 1, a loading and unloading device (not shown) are provided. Each comprises a manipulator for moving the workpiece 4. The workpiece holding devices 1a,b may be moved somewhat further apart in the second direction *x* for mounting and unloading. The manipulator is configured to grip the workpiece 4 and move the workpiece 4 into a mounting position with respect to the workpiece holding device 1 in the case of the mounting device. Likewise, the manipulator of the unloading device is arranged to grip the workpiece 4 and move the workpiece 4 out of the mounted position with respect to the workpiece holding device 1. At that time, the mounting device and unloading device are positioned adjacent the workpiece holding device 1 facing the plane in which the workpiece 4 is arranged to be held. Because the first and second members 9,10 are offset in opposite directions, the workpiece 4 has to be moved around only one of the first and second members 9,10. This is done through a threading movement comprising a pivoting movement of the workpiece 4 about a pivot axis parallel to the longitudinal axes of the first and second members 9,10. One of the leading edge 26 and the trailing edge 27 of the workpiece 4 is thus moved behind that one of the first and second members 9,10 that is on the proximal side of the plane in which the workpiece 4 is held, from the perspective of the mounting device or unloading device concerned. This means that the workpiece holding device 1 can remain attached to the conveyor during the mounting and unloading operations.

This is not the case for a system comprising a second workpiece holding device 29 (Figs. 10-14, 15B), in which every other workpiece holding device 29 has to be pivoted over 180° or mounting and unloading devices have to be arranged on opposite sides of the path of the workpiece holding device 29 and operate on every other workpiece holding device 29.

The second workpiece holding device 29 comprises a plurality of upper clamping devices 30a-d (Figs. 12-14) and a plurality of lower clamping devices 31a-d (Fig. 11) for holding a planar workpiece 32 (Fig. 15B). In the illustrated embodiment, there are equal numbers of upper clamping devices 30a-d and lower clamping devices 31a-d. In alternative embodiments, their number may differ. In particular, there may be fewer lower clamping devices 31a-d. If the workpiece 32 is relatively stiff or has a relatively large mass, the lower clamping devices 31a-d may be dispensed with.

In the illustrated embodiment, at least some of the clamping devices 30a-d,31a-d are arranged electrically to contact at least one, e.g. both, major surfaces of the workpiece 32.

Through their position and configuration, the clamping devices 30a-d,31a-d define the plane in which the workpiece 32 will lie when held by the workpiece holding device 29.

The workpiece holding device 29 comprises a structure surrounding on at least three sides a region 33 of the plane, seen from a direction perpendicular to the plane (Fig. 10). The region 33 does not correspond to the complete area occupied by the workpiece 32. In use, first and second members 34,35 comprised in the structure overlap with edge regions of the workpiece 32.

The first and second members 34,35 are arranged on first and second, opposite, sides of the region 33, seen perpendicular to the plane. The first and second members 34,35 have respective longitudinal axes extending in a first direction z parallel to the plane, which corresponds to an upright, or vertical, orientation of these longitudinal axes, in use. Movement, in use, is in a second direction x parallel to the plane and transverse to the first direction.

In the illustrated embodiment, the structure surrounding the region 33 on at least three sides, seen perpendicular to the plane, actually surrounds the region 33 on four sides, so that the region 33 appears to be framed. The structure comprises an upper interconnecting part 36 and a lower (also referred to as further) interconnecting part 37. The upper clamping devices 2a-d are supported by the upper interconnecting part 36. The lower clamping devices 31a-d are supported by the lower interconnecting part 37.

In the illustrated embodiment, a hanger arm 38 (Fig. 10) is attached to the upper interconnecting part 36. The hanger arm 38 is comprised in an overhead conveyor system for transporting the workpiece holding device 29 in the second direction *x*. The workpiece holding device 29 is suspended from the hanger arm 38. In alternative embodiments, hooks like those forming the first and second parts 13,14 of the first workpiece holding device 1 for attachment of the upper interconnecting part 11 of the first workpiece holding device 1 to a conveyor may be used to attach the second workpiece holding device 29 to the conveyor.

At least the longitudinal axes of the first and second members 34,35 are offset with respect to the plane, a direction perpendicular to the plane. This direction is also perpendicular to the first and second directions *z,x*. In contrast to the first workpiece holding device 1, the first and second members 34,35 of any one workpiece holding device 29 are offset in the same direction. They are thus on the same side of the plane.

In the illustrated embodiment, the first and second members 34,35 are entirely offset with respect to the plane. They may be spaced apart from the plane by a distance equal to at least half the thickness of the workpiece 32 that the workpiece holding device 29, more particularly the clamping devices 30a-d,31a-d, are configured to hold. This may be a distance in the order of millimetres, e.g. at least 1, 2 or 5 mm.

In the illustrated embodiment, the upper interconnecting part 36 comprises a third member 39 (Figs. 10, 13 and 14), extending in the second direction *x*. The first and second members 34,35 are connected to the third member 39 at opposite ends of the third member 39 by mounting plates (not shown in detail) to which they are fixed, e.g. by welding. The mounting plates are fixed to the third member 39 by fasteners (not shown), e.g. screws. In alternative embodiments, the first and second members 34,35 may be welded or adhesively bonded directly to the third member 39. In yet another alternative embodiment, fixing devices such as the fixing devices 16,17 of the first workpiece holding device 1 may be used to make the locations of engagement between the upper interconnecting part 36 and the first member 34 and second member 35, respectively, variable in the first direction *z*.

The upper clamping devices 30a-d are mounted to a support member 40 (Fig. 13) in fixed positions by fasteners, e.g. bolts or screws. The support member 40 is journalled for movement relative to the third member 39 in the first direction *z*. Biasing devices 41a-c bias the support member 40 and thus the upper clamping devices 30a-f away from the region 33 in the first direction *z*. In the illustrated embodiment, the biasing devices 41a-c act on the support member 40 and the third member 39. In the illustrated embodiment, the biasing devices 41a-c are helical tension springs. In other embodiments, gas springs might be used, for example. In the illustrated embodiment, the biasing devices 41a-c are pre-tensioned and the pre-tension is adjustable.

The movably journalled support member 40 facilitates the mounting of the workpiece 32 to the workpiece holding device 29. The biasing due to the biasing devices 41a-c also contributes to this effect and stretches thin and flexible planar workpieces 32 in the first direction *z*.

The lower interconnecting part 37 comprises a fourth member 42, extending in the second direction *x*. The first and second members 34,35 are connected to the fourth member 42 at opposite ends of the fourth member 42. The first and second members 34, 35 may be welded or otherwise joined to first and second mounting blocks mounted to the fourth member 42 to define the offsets with respect to the plane in which the clamping devices 30a-d,31a-d are arranged to hold the workpiece 32.

The lower clamping devices 31a-d are mounted to the fourth member 42 in fixed positions by fasteners, e.g. bolts or screws.

In other embodiments, the mounting blocks may be replaced by fixing devices such as the first and second fixing devices 16,17 of the first workpiece holding device 1.

In the illustrated embodiment, first and second follower parts 43,44 (Figs. 10, 11) are mounted to the fourth member 42 and protrude outwards from the fourth member 42 in the first direction *z*. The follower parts 43,44 interact with the guide 25 (Fig. 1) defining a path through the tank 6 in the first direction *x*. Again, other types of follower parts 43,44 than guide rollers for engaging the guide 25 are conceivable.

In the illustrated embodiment, the first and second members 34,35 are cylindrical in shape, with a circular cross-section, over at least majority of their respective lengths. This encompasses central sections extending between the third and fourth members 39,42. Other cross-sectional shapes, such as square, are conceivable, in particular also in sections at one or both longitudinal ends of the first and second members 34,35. A circular cross-sectional shape allows for deflections with little risk of damage, should the workpiece 32 touch the first or second member 34,35 during mounting or unloading of the workpiece 32 to or from the workpiece holding device 29. Furthermore, the flow of processing liquid over the surface of the workpiece 32 due to movement of the workpiece holding device 29 in the second direction *x* is less turbulent. Other cross-sectional shapes are more appropriate for fixing the ends of the first and second members 34,35 to the third and fourth members 39,42.

For electrochemical treatment purposes, at least a surface of the first and second members 34,35 is formed by electrically insulating material along at least a majority of their respective lengths. This includes a central section of each of the first and second member 34,35. In one embodiment, the first and second members 34,35 are made entirely of electrically insulating material. Alternatively, they may be made of metal or a metal alloy and provided with an electrically insulating sheath or coating over at least a majority of their respective lengths. In all embodiments, the first and second members 34,35 may be tubular. This saves weight. Moreover, an electrical cable may be arranged inside at least one of the first and second members 34,35. This can be useful in an embodiment in which the lower clamping devices 31a-d are configured to contact one or both major surfaces of the workpiece 32 electrically. A similar effect can be achieved if one or both of the first and second members 34,35 are provided with an electrically conducting core and an electrically insulating cladding.

In a system comprising two second workpiece holding devices 29 (Fig. 15B), successive workpiece holding devices 29 are attached to the conveyor such that there is a gap between a leading edge 45 of the workpiece 32a held by an upstream workpiece holding device 29 and a trailing edge 46b of a workpiece 32b held by a downstream workpiece holding device 29. A first member 34a of the upstream workpiece holding device 29 faces a second member 35b of the downstream workpiece holding device 29 across the gap. This

is because the two workpiece holding devices 29 face in opposite direction, such that first member 34a and the second member 35b are offset in opposite directions perpendicular to the planes in which the workpiece holding devices 29 are arranged to hold the respective workpieces 32a,b. The distances by which first member 34a and the second member 35b are offset with respect to the respective planes are at least approximately equal in the illustrated embodiment.

When a potential difference is applied between the anodes 5a,b and the workpieces 32a,b, the first member 34a and second member 35b facing each other across the gap between the leading edge 45a and the trailing edge 46b provide a shielding effect. Electric field lines 47a,b are deflected from edge regions of the workpieces 32a,b. The offset distance to the plane in which the workpieces 32a,b are held can be optimised for surface uniformity at the edges 45a,46b.

The invention is not limited to the embodiments described above, which may be varied within the scope of the accompanying claims. For example, the lower interconnecting parts 12,37 may be omitted and the upper interconnecting parts 11,36 formed as an assembly for holding the first and second members 9,10;34,35 at a variable distance to each other in the second direction *x*. A way of doing this is disclosed in WO 2018/225535 A1, for example.

List of reference numerals

1	-	First workpiece holding device
2a-f; 30a-d	-	Upper clamping devices
3a-f; 31a-d	-	Lower clamping devices
4; 32	-	Workpiece
5a,b	-	Anodes
6	-	Tank
7a,b	-	Spray bars
8;33	-	Plane region
9; 34	-	First member
10; 35	-	Second member
11; 36	-	Upper interconnecting part
12; 37	-	Lower interconnecting part
13	-	First part for attachment to a conveyor
14	-	Second part for attachment to a conveyor
15; 39	-	Third member
16	-	First fixing device
17	-	Second fixing device
18; 40	-	Support member
19a-c; 41a-c	-	Biasing devices
20; 42	-	Fourth member
21	-	First mounting block
22	-	Second mounting block
23; 43	-	First follower part
24; 44	-	Second follower part
25	-	Guide
26; 45	-	Leading edge
27b; 46	-	Trailing edge
28a-d; 47a-d	-	Electric field lines
29	-	Second workpiece holding device
38	-	Hanger arm

Claims

1. Device for holding a planar workpiece (4) in a bath of an apparatus for wet-chemical treatment of the workpiece (4), the device comprising:

at least one clamping device (2,3) for holding the workpiece (4) in a plane;

a structure surrounding on at least three sides, seen perpendicular to the plane and in the absence of the workpiece, a region (8) of the plane,

wherein the structure comprises a first member (9) and a second member (10), arranged on first and second sides of the region (8) and having respective longitudinal axes extending in a first direction (*z*) parallel to the plane, and

wherein the structure comprises an interconnecting part (11) interconnecting the first and second members (9,10) on a third side of the region (8); and

at least one part (13) for attachment of the interconnecting part (11) to a conveyor for transporting the device in a second direction (*x*) parallel to the plane and transverse to the first direction (*z*),

characterised in that

the longitudinal axes are offset with respect to the plane in opposite directions perpendicular to the plane.

2. Device according to claim 1,

wherein the interconnecting part (11) is releasably connected to at least one of the first and second members (9,10) by a respective fixing device (16,17), and

wherein a location of engagement between the fixing device (16,17) and the one of the first and second members (9,10) concerned is variable in the first direction (*z*).

3. Device according to claim 1 or 2,

wherein at least one of the at least one clamping devices (2) is supported by the interconnecting part (11).

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

wherein the interconnecting part (11) comprises a third member (15), extending in the second direction (*x*), and

wherein the first and second members (9,10) are connected to the third member (15) at opposite ends of the third member (15).

5. Device according to claims 3 and 4,

wherein the clamping devices (2) supported by the interconnecting part (11) are supported by the third member (15).

6. Device according to claim 3 or 5,

wherein the clamping devices (2) supported by the interconnecting part (11) are journalled for movement in the first direction (*z*) relative to the interconnecting part (11), and

wherein the device comprises at least one biasing device (19a-c) for biasing the clamping devices (2) journalled for movement away from the region (8) in the first direction (*z*).

7. Device according to claim 6,

wherein a plurality of clamping devices (2) are mounted to a single common support member (18) journalled for movement in the first direction (*z*) relative to the interconnecting part (11), and

wherein the at least one biasing devices (19a-c) act on the common support member (18).

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

wherein the structure comprises a further interconnecting part (12) interconnecting the first and second members (9,10) and located on a fourth side of the region (8).

9. Device according to claim 8,

wherein at least one of the clamping devices (3) is supported by the further interconnecting part (12).

10. System for conveying planar workpieces (4;32) through a bath of an apparatus for wet-chemical treatment of the workpieces (4;32),

wherein the system comprises a plurality of workpiece holding devices (1;29), each workpiece holding device (1;29) comprising:

at least one clamping device (2,3;30,31) for holding the workpiece (4;32) in a plane; and

a structure surrounding on at least three sides, seen perpendicular to the plane and in the absence of the workpiece, a region (8) of the plane,

wherein the structure comprises a first member (9;34) and a second member (10;35), arranged on first and second sides of the region (8) and having respective longitudinal axes extending in a first direction (*z*) parallel to the plane, and

wherein the system further comprises a conveyor for transporting the workpiece holding devices (1;29) in a second direction (*x*) parallel to the plane and transverse to the first direction (*z*), **characterised in that,**

the longitudinal axis of a leading one of the first and second members (9,10;34,35) of a first of the workpiece holding devices (1;29), seen in the second direction (*x*), and the longitudinal axis of a trailing one of the first and second members (9,10) of a next one of the workpiece holding device (1;29) in the second direction (*x*) are offset with respect to the respective planes of these workpiece holding devices (1;29) in opposite directions perpendicular to the planes such that the leading member (9,10;34,35) of the first workpiece holding device (1;29) and the trailing member (9,10) of the next workpiece holding device (1;29) at least partially face each other.

11. System according to claim 10,

wherein the workpiece holding devices (1) are devices according to any one of claims 1-9.

12. System according to claim 10,

wherein, in each workpiece holding device (29), the first and second members (34,35) are provided on the same side of the plane.

13. System according to any one of claims 10-12,

wherein the conveyor is an overhead conveyor and the workpiece holding devices (1;29) are suspended from the overhead conveyor.

14. Apparatus for wet-chemical treatment of planar workpieces (4;32), comprising at least one system according to any one of claims 10-13.

15. Method of conveying planar workpieces (4;32) through a bath of an apparatus for wet-chemical treatment of the workpieces,

wherein the workpieces (4;32) are mounted in respective workpiece holding devices (1;29), each workpiece holding device (1;29) comprising:

at least one clamping device (2,3;30,31) for holding the workpiece (4;32) in a plane; and

a structure surrounding on at least three sides, seen perpendicular to the plane and in the absence of the workpiece, a region (8;33) of the plane,

wherein the structure comprises a first member (9;34) and a second member (10;35), arranged on first and second sides of the region (8;33) and having respective longitudinal axes extending in a first direction (*z*) parallel to the plane,

wherein the workpiece holding devices (1;29) are conveyed in a second direction (*x*) parallel to the plane and transverse to the first direction (*z*), such that a trailing edge (27;46) of a first workpiece (4;32) is separated from a leading edge (26;45) of a second workpiece (4;32) by a gap, **characterised in that**

one of the first and second members (9,10;34,35) of the workpiece holding device (1;29) in which the first workpiece (4;32) is mounted and one of the first and second members (9,10;34,35) of the workpiece holding device (1;29) in which the second workpiece (4) is mounted face each other across the gap.

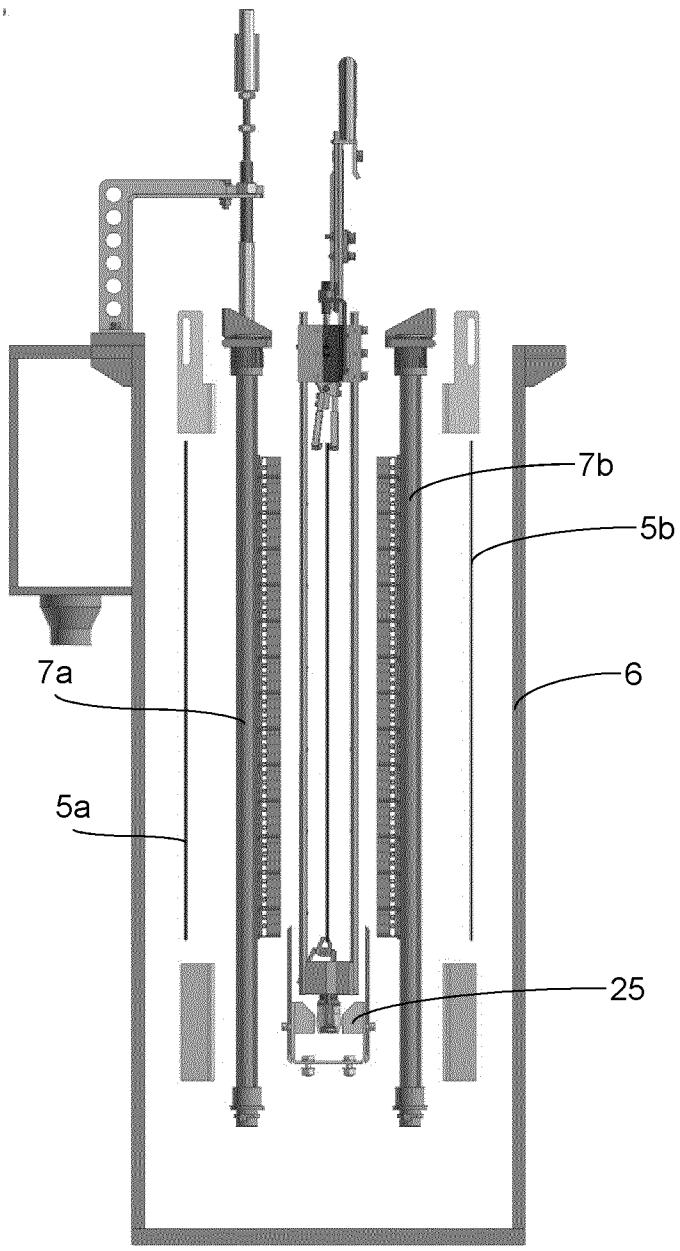


Fig. 1

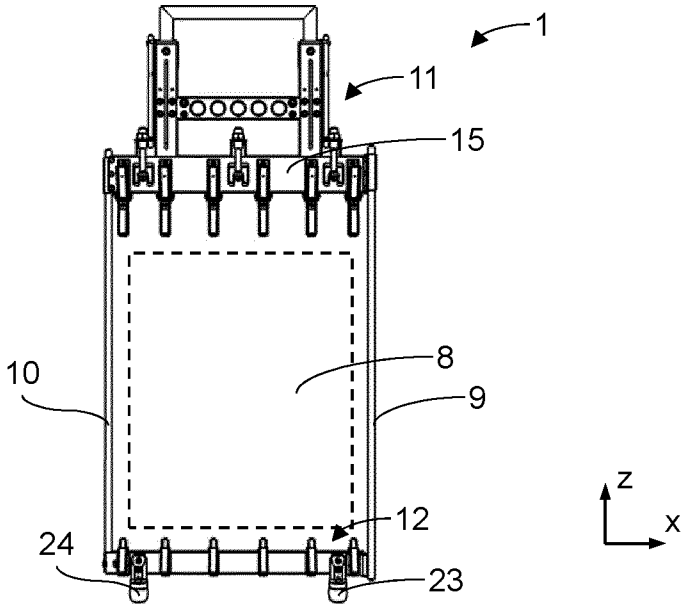


Fig. 2

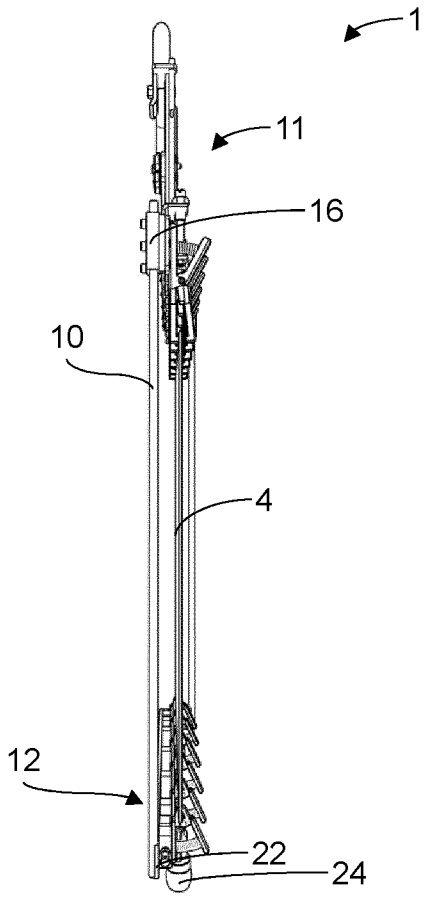


Fig. 3

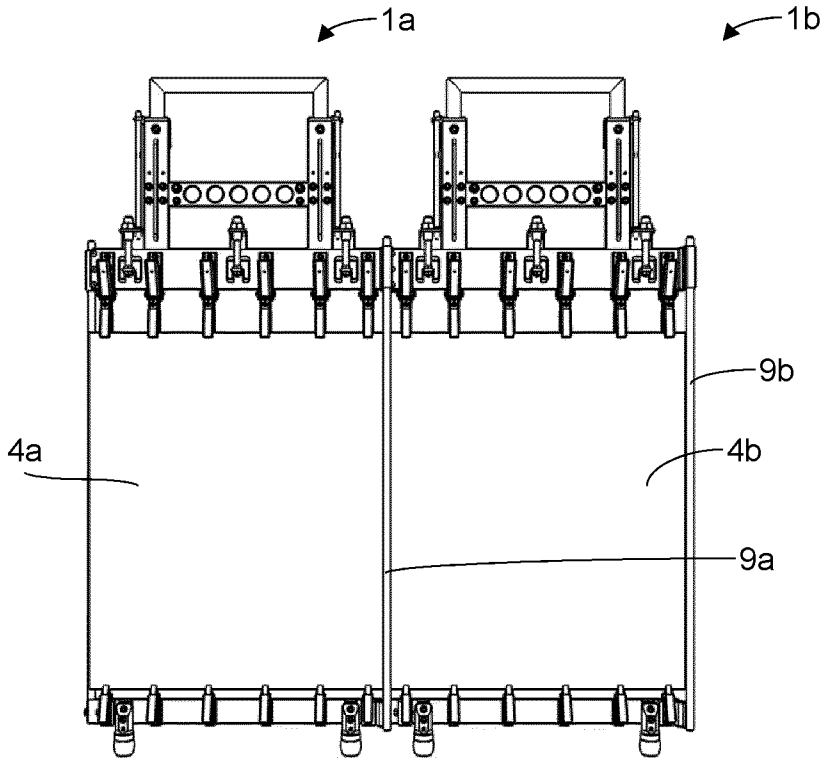


Fig. 4

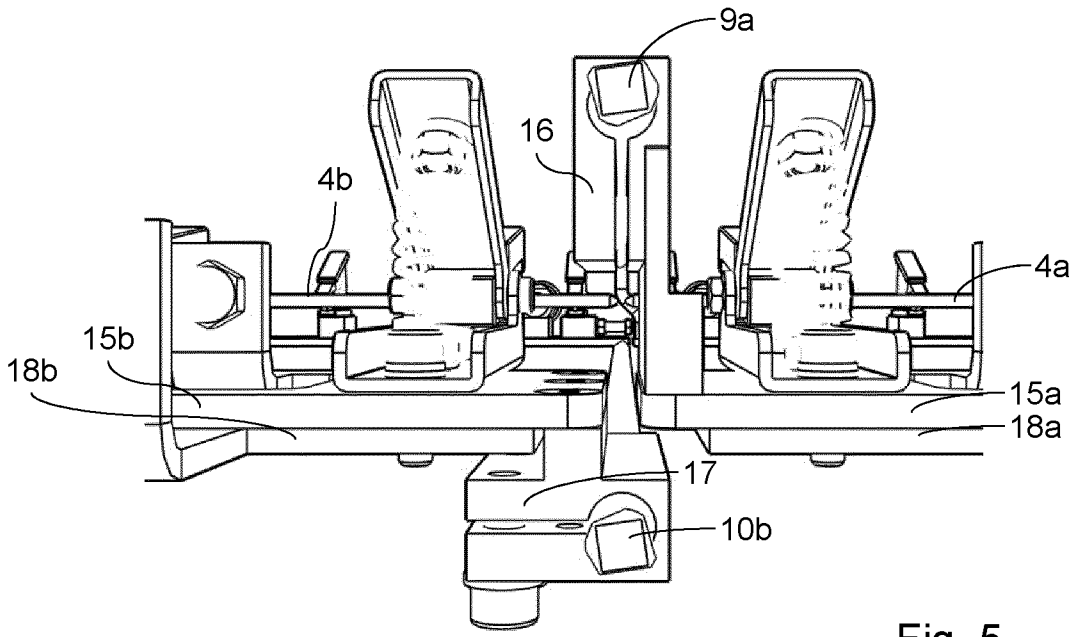


Fig. 5

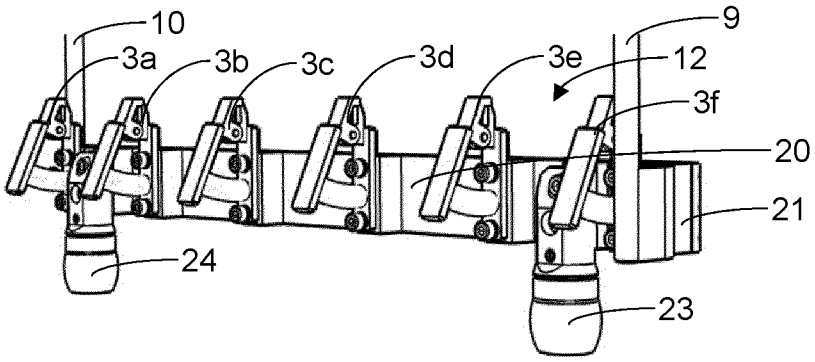


Fig. 6

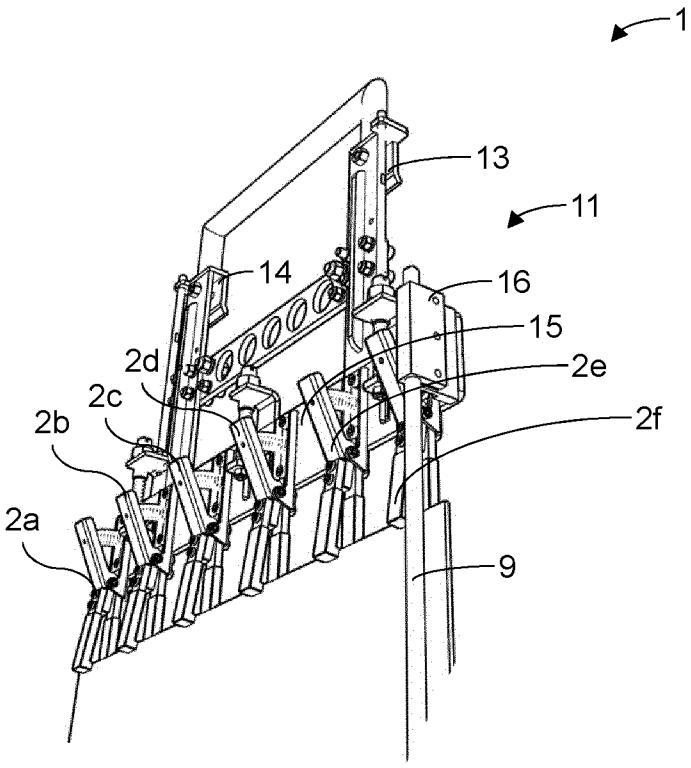


Fig. 7

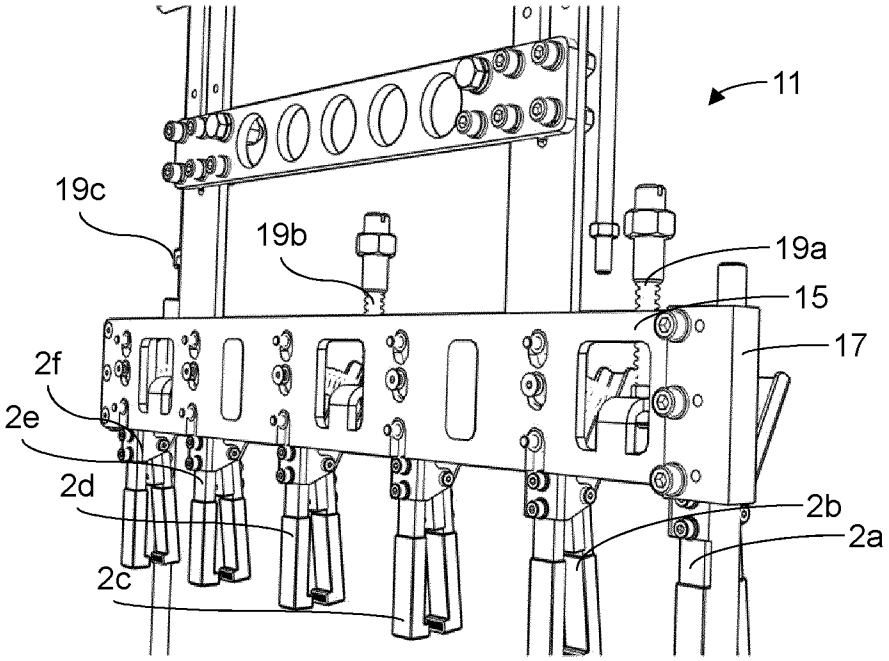

11
19c
19b
19a
15
17
2f
2e
2d
2b
2a
2c

Fig. 8

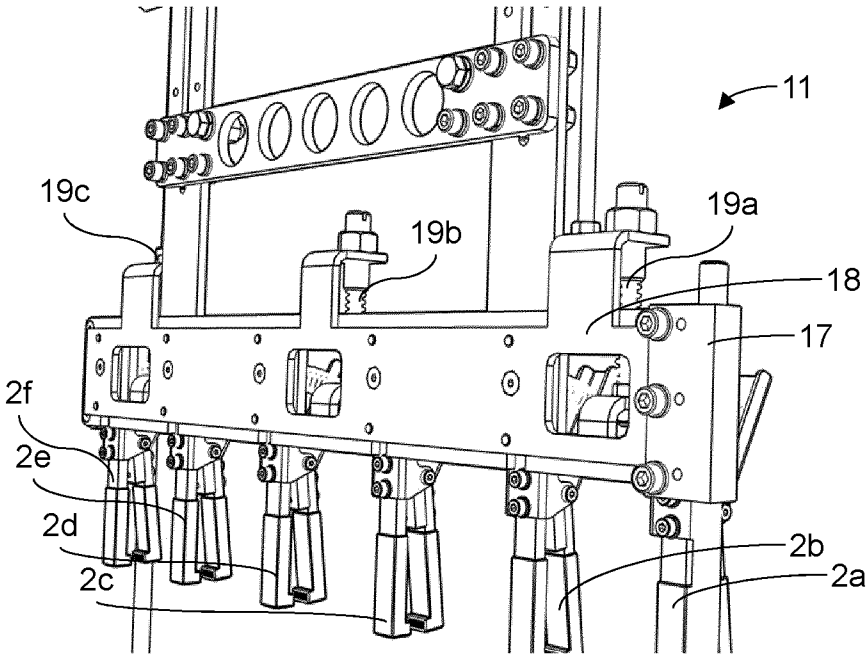

11
19c
19b
19a
18
17
2f
2e
2d
2b
2a
2c

Fig. 9

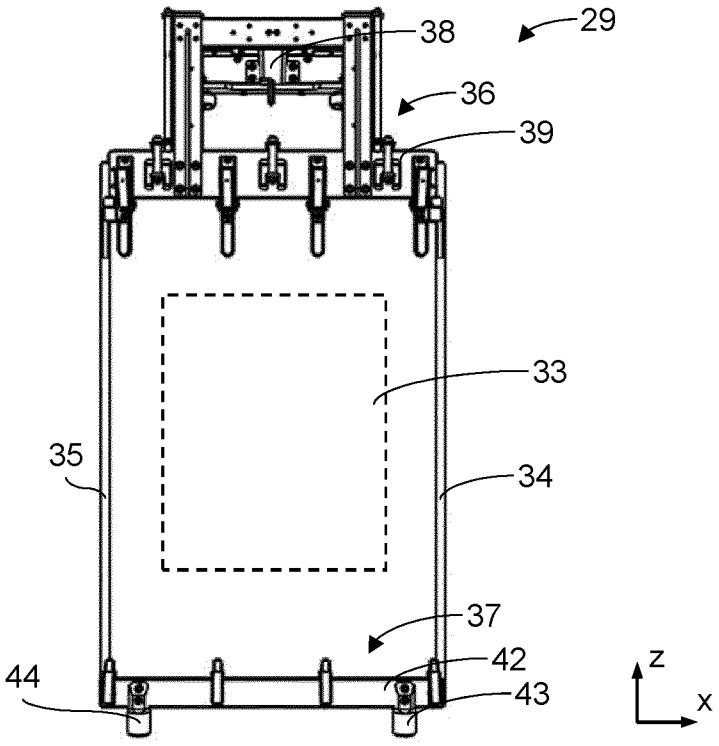


Fig. 10

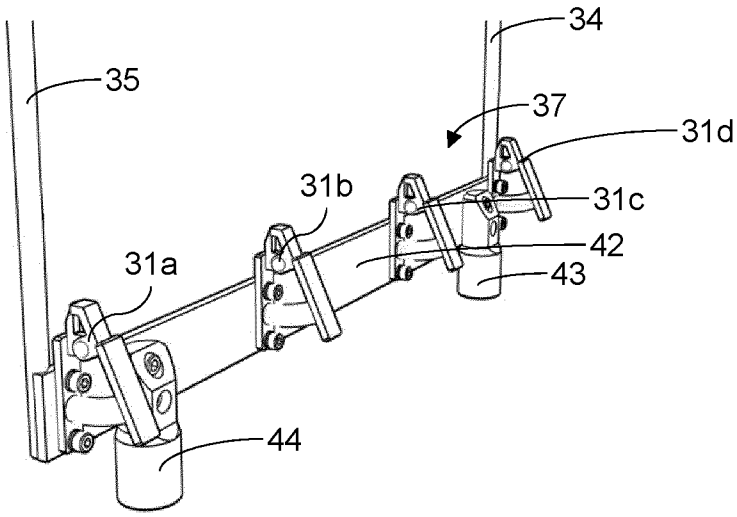


Fig. 11

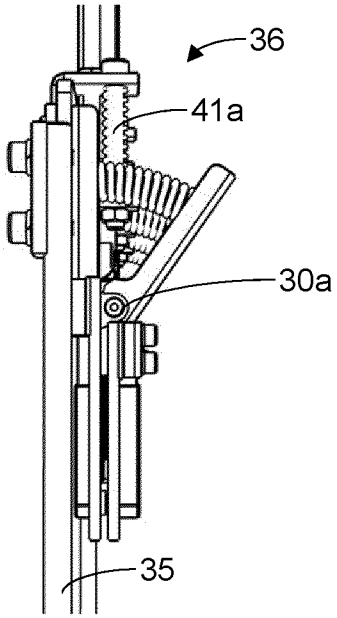


Fig. 12

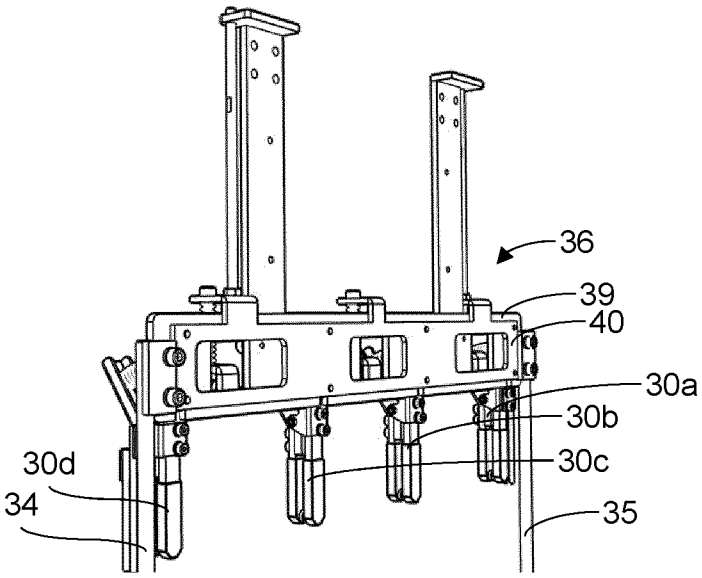


Fig. 13

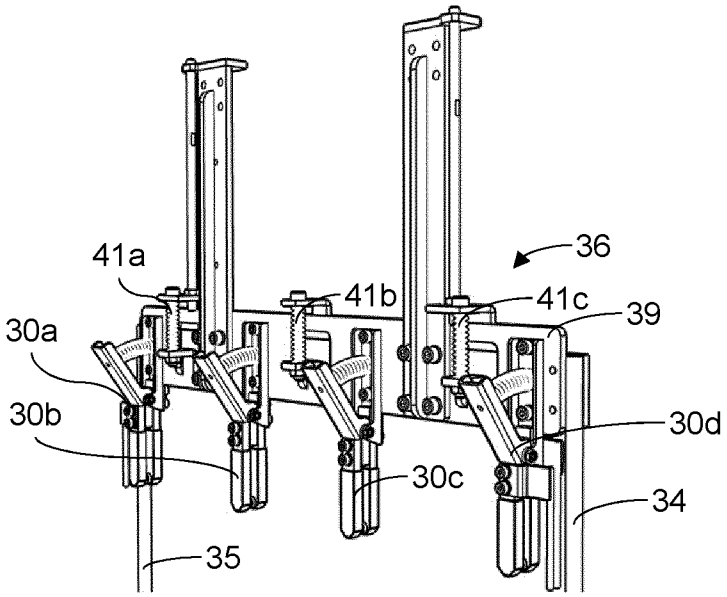


Fig. 14

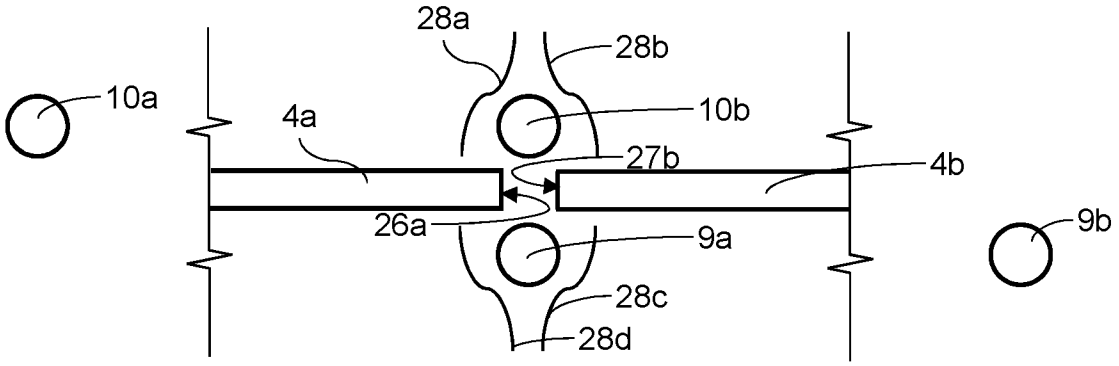


Fig. 15A

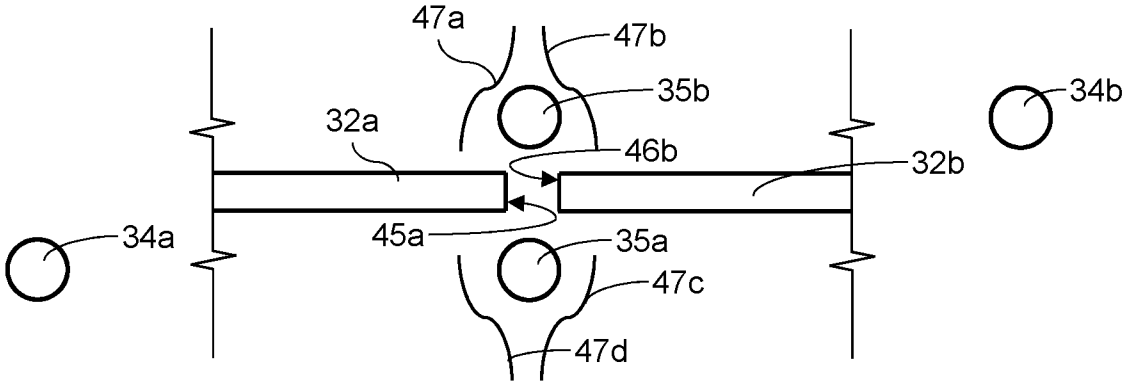


Fig. 15B

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2023/071943

A. CLASSIFICATION OF SUBJECT MATTER
INV. C25D17/06 C25D17/00
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
C25D

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

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2020/158570 A1 (ALMEX PE INC [JP]) 6 August 2020 (2020-08-06)	1,3-5, 8-15
Y	paragraph [0001]; figures 1, 5, 20-22 paragraph [0004] - paragraph [0006] paragraph [0026] paragraph [0029] paragraph [0034] - paragraph [0035] paragraph [0086] - paragraph [0087] paragraph [0092] -----	2,6,7
X	US 2013/001087 A1 (ASA FUJIO [JP] ET AL) 3 January 2013 (2013-01-03)	15
Y	paragraph [0091] - paragraph [0093]; figures 1-4, 16, 17 paragraph [0133] - paragraph [0134] -----	2,6,7
A	JP 6 041927 B2 (ALMEX PE INC) 14 December 2016 (2016-12-14) paragraph [0052]; figures 3, 8, 9 -----	1-15

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

☒ See patent family annex.

* Special categories of cited documents :

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance;; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

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

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
27 October 2023	06/11/2023

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

1

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
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