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(71) Applicant *(for all designated States except US)*: **DEK INTERNATIONAL GMBH** [CH/CH]; Hardturmstrasse 101, CH-8005 Zürich (CH).

(72) Inventors; and
(75) Inventors/Applicants *(for US only)*: **LIESKE, Richard, John** [US/US]; 1061 West 7th Street, Winona, MN 55987 (US). **BAILEY, Lee, Edward, James** [GB/GB]; 305 Dorchester Road, Weymouth, Dorset DT3 5JA (GB). **LEE, Tsung En** [—/GB]; 21 Merredin Close, Weymouth, Dorset DT3 6SJ (GB).

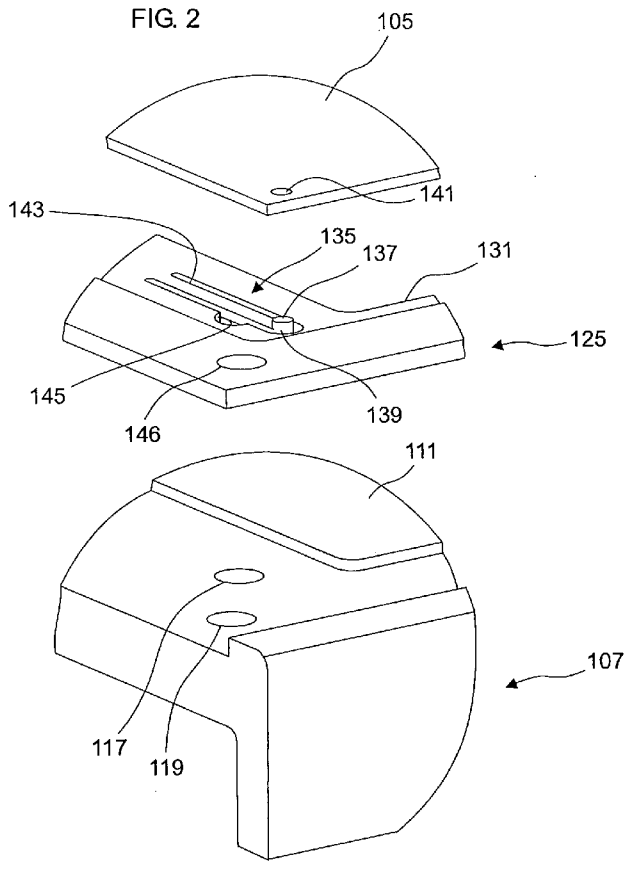
(74) Agent: **BODEN, Keith, McMurray**; FRY HEATH & SPENCE LLP, The Gables, Massetts Road, Horley, Surrey RH6 7DQ (GB).

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(54) Title: WORKPIECE CARRIER AND WORKPIECE CARRIER LOADING/UNLOADING SYSTEM AND METHOD



(57) Abstract: A workpiece carrier for supporting a plurality of workpieces, preferably flexible workpieces, the workpiece carrier comprising : a plurality of workpiece supports, each for supporting a workpiece; and a plurality of workpiece positioners, each associated with a respective one of the workpiece supports and being operative to position a workpiece at a predetermined position in the respective workpiece support, wherein the workpiece positioners each comprise a plurality of biasing elements which are disposed in opposed relation and configured laterally outwardly to bias the workpiece to tension the workpiece and position the workpiece at the predetermined position.

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WORKPIECE CARRIER AND WORKPIECE CARRIER LOADING/UNLOADING SYSTEM AND METHOD

The present invention relates to a workpiece carrier for supporting a plurality of workpieces, and a workpiece carrier loading/unloading system and method for loading and unloading workpieces into and from such a workpiece carrier.

The continuous development of electronics is resulting in more complex systems being contained in smaller components, leading to the use of smaller printed circuit boards. One example is the mobile telephone, where progressively smaller mobile telephones are being developed which have at least the same, if not increased, functionality.

Traditionally, in handling small printed circuit boards, the practice was to fabricate the printed circuit boards as an array of separable panels in a single, large board, thereby allowing the printed circuit boards to be handled as a single entity. This approach has been used successfully, but the increased accuracy required by the newer, smaller components cannot be achieved by this technique. As a result, such small printed circuit boards have again to be handled separately.

In addition, larger electronic components are being developed as increased functionality is integrated into a single integrated circuit and more than one integrated circuit plus resistors and capacitors are assembled onto a substrate, such as a ball grid array (BGA) substrate or a pin grid array (PGA) substrate, to form a single component. These larger electronic components have also to be handled separately.

For handling such workpieces, workpiece carriers have been developed which allow a plurality of workpieces to be transported simultaneously to a machine, such as a screen printing machine or a placement machine, for operation by the machine. Such workpiece carriers include those

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manufactured to the JEDEC (Joint Electron Device Engineering Council) standard.

Figure 8 illustrates one such workpiece carrier 3 which is used to support a plurality of workpieces 5 in transporting the same to a machine for operation. For the purposes of illustration, the workpiece carrier 3 is illustrated only partially filled with workpieces 5.

The workpiece carrier 3 comprises a plate 7 which includes a plurality of support elements 9, in this embodiment ten support elements 9 arranged in pairs in a 2 x 5 array, for supporting respective ones of the workpieces 5.

The plate 7 comprises lower and upper plate parts 7a, 7b which are fixed together by suitable means, such as by bonding, spot welding and riveting.

The support elements 9 each comprise a through aperture 11, in this embodiment a square aperture, and a plurality of support members 15 which are disposed about the periphery of the aperture 11, in this embodiment four support members 15 which are located at respective ones of the sides of the aperture 11, for supporting the respective edges of a workpiece 5. The support members 15 of each support element 9 are spaced from the upper surface of the plate 7 such as to define a recess for receiving a workpiece 5, whereby the upper surface of a workpiece 5, when supported by the respective support element 9, is substantially co-planar with the upper surface of the plate 7.

The workpiece carrier 3 further comprises a plurality of workpiece-retaining elements 17, in this embodiment each comprising a plurality of pillars 19, for retaining workpieces 15 in the respective ones of the support elements 9. In this embodiment the workpiece-retaining elements 17 each comprise eight pillars 19, each pillar 19 being located adjacent a respective corner of the respective support element 9, such as to retain a workpiece 5 captive therewithin.

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Typically, in the fabrication of an electronic device, a viscous solder paste is first applied to selected areas of a workpiece, such as a substrate, for example, a printed circuit board, through a stencil in a screen printing machine. Electronic components are then placed on the applied solder paste using a placement machine, often referred to as a pick-and-place machine. The workpiece and components are then heated in a re-flow oven to a temperature sufficient to melt the solder paste, causing the solder paste to flow under leads of the components and corresponding pads of the workpiece, thereby forming solder joints and completing the electronic device.

The use of a workpiece carrier enables a plurality of workpieces to be transported simultaneously to a machine, thereby providing for transport efficiencies, but, where the workpieces are only roughly positioned on the workpiece carrier, each workpiece has to be handled individually in operation by the machine in order to establish the position of the supported workpiece. For example, in a screen printing machine, the workpieces are successively supported by a single vacuum tower and the stencil successively positioned by an X-Y table above each workpiece as supported by the vacuum tower, with each workpiece, when so positioned, being subject to a separate printing operation. As will be appreciated, such repeated re-positioning of the stencil for each supported workpiece is particularly time consuming, as is the requirement to print each workpiece individually. In a placement machine, for example, the workpieces are successively supported by a single vacuum tower and the robotic pick-and-place arm is re-referenced to the position of the workpiece. Again, such referencing of the pick-and-place robotic arm for each supported workpiece is time consuming.

As disclosed in WO-A-2002/089551, the present applicant has previously developed a tooling fixture which allows for the simultaneous, individual positioning of a plurality of workpieces as supported by such mentioned workpiece carriers, thereby enabling a single operation of a machine without any re-positioning or re-referencing. For example, in a screen printing

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machine, the tooling fixture allows for the printing of a plurality of workpieces in a single printing operation without any re-positioning of the stencil. In a placement machine, for example, the tooling fixture allows for the placement of components on a plurality of workpieces in a single operation without any re-referencing of the pick-and-place robotic arm.

It is an aim of the present invention to provide an improved workpiece carrier which automatically provides for the precise individual positioning of a plurality of workpieces, in particular flexible workpieces, when loaded thereon and does not require any subsequent positioning operations to align the workpieces to the workpiece carrier.

In one aspect the present invention provides a workpiece carrier for supporting a plurality of workpieces, preferably flexible workpieces, the workpiece carrier comprising: a plurality of workpiece supports, each for supporting a workpiece; and a plurality of workpiece positioners, each associated with a respective one of the workpiece supports and being operative to position a workpiece at a predetermined position in the respective workpiece support, wherein the workpiece positioners each comprise a plurality of biasing elements which are disposed in opposed relation and configured laterally outwardly to bias the workpiece to tension the workpiece and position the workpiece at the predetermined position.

In one embodiment the workpiece positioners are each configured automatically to position a workpiece at the predetermined position in the respective workpiece support when loaded thereinto, without requiring any subsequent positioning operations.

In one embodiment the workpiece positioners are each configured such that workpieces are repeatedly positioned at the predetermined position when loaded into the respective workpiece support.

In one embodiment the workpiece supports each include a support platform for supporting a workpiece over the surface thereof.

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In one embodiment the biasing elements are configured laterally to engage respective engagement features of a workpiece and apply an outwardly-directed biasing force thereto.

In one embodiment the engagement features comprise recesses.

In one embodiment the engagement features comprise through apertures.

In one embodiment the workpiece positioners each comprise first and second pairs of biasing elements.

In one embodiment the biasing elements have matched biasing forces.

In one embodiment the biasing elements comprise spring elements.

In one embodiment the spring elements each comprise a spring contact for engaging an engagement feature of a workpiece when supported on the respective workpiece support, and a spring arm which is deflectable inwardly and operative resiliently to bias the spring contact laterally outwardly.

In one embodiment the spring contact has an arcuate workpiece-contact face.

In one embodiment the spring arm is operative to bias the spring contact laterally outwardly.

In one embodiment the spring arm is substantially linear.

In one embodiment the workpieces are substantially rectangular, and the spring arms are configured to extend substantially parallel to one opposite pair of sides of the respective workpiece.

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In another embodiment the workpieces are substantially rectangular, and the spring arms are inclined to one opposite pair of sides of the respective workpiece.

In another embodiment the spring arm is arcuate.

In one embodiment the spring elements are configured to apply a tensive force with force components along a single axis.

In another embodiment the spring elements are configured to apply a tensive force with force components through a central region of the respective workpiece.

In one embodiment the spring elements are configured to apply a tensive force with force components through substantially the center of the respective workpiece.

In one embodiment the workpiece carrier comprises: a support member which provides the workpiece supports.

In one embodiment the support member comprises a plate member.

In one embodiment the workpiece carrier comprises: a positioning member which provides the workpiece positioners.

In one embodiment the positioning member comprises a sheet body which defines the workpiece positioners.

In one embodiment the sheet body is of spring steel.

In another aspect the present invention provides a workpiece carrier loading/unloading system, comprising: a workpiece carrier for supporting a plurality of workpieces, preferably flexible workpieces, the workpiece carrier comprising: a plurality of workpiece supports, each for supporting a

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workpiece; and a plurality of workpiece positioners, each associated with a respective one of the workpiece supports and being operative to position a workpiece at a predetermined position in the respective workpiece support, wherein the workpiece positioners each comprise a plurality of biasing elements which are disposed in opposed relation and configured laterally outwardly to bias the workpiece to tension the workpiece and position the workpiece at the predetermined position; and a workpiece loading/unloading assembly for loading and unloading workpieces into and from the workpiece supports of the workpiece carrier.

In one embodiment the workpiece carrier loading/unloading assembly comprises a body unit for supporting the workpiece carrier, and a plurality of actuator units, which are disposed to the body unit in an arrangement corresponding to the workpiece supports of the workpiece carrier and are operable to allow for loading and unloading of workpieces into and from the workpiece supports of the workpiece carrier in loading and unloading operations.

In one embodiment the workpiece carrier loading/unloading assembly comprises a plurality of positioning elements which act to fix the position of the workpiece carrier when mounted on the body unit.

In one embodiment the actuator units each comprise a plurality of actuator pins which are operable between a first, actuated position in which the actuator pins engage the biasing elements of the respective workpiece support and configure the biasing elements to allow loading or unloading of a workpiece, and a second position in which the biasing elements are configured to tension a workpiece when supported on the workpiece support.

In one embodiment, when the workpiece carrier is mounted on the body unit, the actuator pins are located adjacent the spring arms of the spring elements of the respective workpiece support and operation of the actuator pins to the actuated position acts to deflect the spring arms inwardly.

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In a further aspect the present invention provides a method of loading workpieces into a workpiece carrier, comprising the steps of: providing a workpiece carrier for supporting a plurality of workpieces, preferably flexible workpieces, the workpiece carrier comprising: a plurality of workpiece supports, each for supporting a workpiece; and a plurality of workpiece positioners, each associated with a respective one of the workpiece supports and being operative to position a workpiece at a predetermined position in the respective workpiece support, wherein the workpiece positioners each comprise a plurality of biasing elements which are disposed in opposed relation and configured laterally outwardly to bias the workpiece to tension the workpiece and position the workpiece at the predetermined position; providing a workpiece loading assembly for loading workpieces into the workpiece supports of the workpiece carrier; and utilizing the workpiece loading assembly to load workpieces into the workpiece supports of the workpiece carrier.

In one embodiment the workpiece carrier loading assembly comprises a body unit for supporting the workpiece carrier, and a plurality of actuator units, which are disposed to the body unit in an arrangement corresponding to the workpiece supports of the workpiece carrier, and the step of utilizing the workpiece loading assembly comprises the steps of: first operating one or more of the actuator units to engage the biasing elements of the respective workpiece positioners and position the same to receive workpieces; loading workpieces onto the respective workpiece supports; and second operating the one or more of the actuator units to release the biasing elements of the respective workpiece positioners to tension the supported workpieces.

In one embodiment the actuator units each comprise a plurality of actuator pins which are operable between a first, actuated position in which the actuator pins engage the biasing elements of the respective workpiece positioner and configure the biasing elements to allow loading of a workpiece and a second, released position in which the biasing elements are

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configured to tension a workpiece when supported on the workpiece support, the first operating step comprises the step of moving the actuator pins to the actuated position in which the actuator pins engage the biasing elements of the respective workpiece positioner and configure the biasing elements to allow loading of a workpiece, and the second operating step comprises the step of moving the actuator pins to release the biasing elements of the respective workpiece positioner and configure the biasing elements to tension the supported workpiece.

In one embodiment the biasing elements comprise spring elements, which each comprise a spring contact for engaging an engagement feature of a workpiece when supported on the respective workpiece support, and a spring arm which is deflectable inwardly and operative resiliently to bias the spring contact laterally outwardly, and, when the workpiece carrier is mounted on the body unit, the actuator pins are located adjacent the spring arms of the spring elements of the respective workpiece positioner and operation of the actuator pins to the actuated position acts to deflect the spring elements inwardly.

In a yet further aspect the present invention provides a method of unloading workpieces from a workpiece carrier, comprising the steps of: providing a workpiece carrier for supporting a plurality of workpieces, preferably flexible workpieces, the workpiece carrier comprising: a plurality of workpiece supports, each for supporting a workpiece; and a plurality of workpiece positioners, each associated with a respective one of the workpiece supports and being operative to position a workpiece at a predetermined position in the respective workpiece support, wherein the workpiece positioners each comprise a plurality of biasing elements which are disposed in opposed relation and configured laterally outwardly to bias the workpiece to tension the workpiece and position the workpiece at the predetermined position; providing a workpiece unloading assembly for unloading workpieces from the workpiece supports of the workpiece carrier; and utilizing the workpiece unloading assembly to unload workpieces from the workpiece supports of the workpiece carrier.

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In one embodiment the workpiece carrier unloading assembly comprises a body unit for supporting the workpiece carrier, and a plurality of actuator units, which are disposed to the body unit in an arrangement corresponding to the workpiece supports of the workpiece carrier, and the step of utilizing the workpiece unloading assembly comprises the steps of: first operating one or more of the actuator units to engage the biasing elements of the respective workpiece positioners and position the same to release the supported workpieces; and unloading workpieces from the respective workpiece supports.

In one embodiment the actuator units each comprise a plurality of actuator pins which are operable between a first, released position and a second, actuated position in which the actuator pins engage the biasing elements of the respective workpiece positioner and configure the biasing elements to allow unloading of a workpiece, and the operating step comprises the step of moving the actuator pins to the actuated position in which the actuator pins engage the biasing elements of the respective workpiece positioner and configure the biasing elements to allow unloading of a workpiece.

In one embodiment the biasing elements comprise spring elements, which each comprise a spring contact for engaging an engagement feature of a workpiece when supported on the respective workpiece support, and a spring arm which is deflectable inwardly and operative resiliently to bias the spring contact laterally outwardly, and, when the workpiece carrier is mounted on the body unit, the actuator pins are located adjacent the spring arms of the spring elements of the respective workpiece positioner and operation of the actuator pins to the actuated position acts to deflect the spring elements inwardly.

Preferred embodiments of the present invention will now be described hereinbelow by way of example only with reference to the accompanying drawings, in which:

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Figure 1 illustrates a perspective view of a workpiece carrier in accordance with a preferred embodiment of the present invention, as illustrated partially filled with workpieces;

Figure 2 illustrates in enlarged scale an exploded fragmentary perspective view (region A in Figure 1) of the workpiece carrier of Figure 1;

Figure 3 illustrates a workpiece carrier loading/unloading system in accordance with a preferred embodiment of the present invention;

Figure 4 illustrates the workpiece carrier loading/unloading system of Figure 3 with the workpiece carrier of Figure 1 loaded thereon;

Figures 5(a) to (f) illustrate the steps in a loading operation in loading workpieces into a workpiece carrier of the present invention where utilizing the workpiece carrier loading/unloading system of Figure 3;

Figures 5(g) to (l) illustrate the steps in an unloading operation in unloading workpieces from a workpiece carrier of the present invention where utilizing the workpiece carrier loading/unloading system of Figure 3;

Figure 6 illustrates in enlarged scale a fragmentary view of one modified positioning member for the workpiece carrier of Figure 1;

Figure 7 illustrates in enlarged scale a fragmentary view of another modified positioning member for the workpiece carrier of Figure 1; and

Figure 8 illustrates a perspective view of a prior art workpiece carrier for supporting a plurality of workpieces, as illustrated partially filled with workpieces.

Figures 1 and 2 illustrate a workpiece carrier 103 in accordance with a preferred embodiment of the present invention which provides for the precise and automatic individual positioning of a plurality of workpieces 105

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when loaded thereon, without requiring any subsequent positioning operations, typically to enable operation by a machine, such as a printing, deposition or placement machine.

For the purposes of illustration, the workpiece carrier 103 is illustrated only partially filled with workpieces 105.

The workpiece carrier 103 of this embodiment has particular application with flexible workpieces 105, such as flexible strips, for example, ball grid array (BGA) strips, and flexible circuit boards, which do not readily allow for the application of a compressive biasing force, where the application of a compressive load would tend to buckle the workpieces 105. As will be described in more detail hereinbelow, the workpiece carrier 103 of this embodiment acts to tension the supported workpieces 105, both to position the workpieces 105 relative to the workpiece carrier 103 and also render the workpieces 105 flat.

The workpiece carrier 103 comprises a lower, support member 107, in this embodiment a supporting plate, which includes a plurality of workpiece supports/support elements 109, in this embodiment four workpiece support elements 109 arranged in parallel, side-by-side relation, for supporting respective ones of the workpieces 105. In other embodiments the support member 107 could include any number of workpiece support elements 109, which could be arranged in any configuration and have any shape.

In this embodiment the support member 107 is formed of a synthetic material, such as a plastics material or a re-inforced plastics material, and can be machined or moulded. In another embodiment the support member 107 could be formed of a metal.

The workpiece support elements 109 each include a support platform 111, in this embodiment a substantially rectangular, planar platform, for supporting a workpiece 105 over the entire surface thereof. As mentioned hereinabove, the workpiece carrier 103 of this embodiment has particular application to

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flexible workpieces 105, and the support platform 111 provides the necessary support to allow for operation on a supported workpiece 105, such as by means of a squeegee in a printing operation.

The workpiece support elements 109 each further include a plurality of tooling passages 117, in this embodiment through holes, which are located at the respective sides thereof, in this embodiment four tooling passages 117 which are located adjacent the respective corners of the support platform 111. As will be described in more detail hereinbelow, the tooling passages 117 allow for the introduction of tooling in order to effect the loading and unloading of a workpiece 105 into and from the workpiece support element 109 when using a loading/unloading mechanism.

The support member 107 further comprises a plurality of, in this embodiment four positioning recesses 119, here through holes, which are disposed at spaced locations therein, in this embodiment at the corner regions of the support member 107. As will be described in more detail hereinbelow, the positioning recesses 119 are configured to receive positioning elements 206 on a workpiece carrier loading/unloading assembly 203, which is used to load/unload workpieces 105 into and from the workpiece carrier 103, and act to position the workpiece carrier 103 on the workpiece carrier loading/unloading assembly 203.

The support member 107 further comprises a plurality of, in this embodiment four engagement recesses 121 which are disposed at spaced locations therein, in this embodiment at opposite sides of the support member 107. As will be described in more detail hereinbelow, the engagement recesses 121 receive fixing elements 147 which are formed in a positioning member 125 and act to hold together the support member 107 and the positioning member 125 as a unitary structure.

The workpiece carrier 103 further comprises a positioning member 125, in this embodiment formed of a sheet body, which is disposed on the support member 107 and includes a plurality of workpiece positioners/positioning

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elements 129, in this embodiment four workpiece positioning elements 129 arranged in parallel, side-by-side relation and having the same configuration as the workpiece support elements 109 of the support member 107, which act automatically, precisely and individually to position respective ones of the workpieces 105 in relation to the respective workpiece support elements 109, and also function to provide a tensive force to the workpieces 105, which ensures that the workpieces 105 remain flat on the respective support platforms 111. In other embodiments the positioning member 125 could include any number of workpiece positioning elements 129, where having the same configuration and shape as the workpiece support elements 109 of the support member 107.

The workpiece positioning elements 129 each include a through aperture 131, in this embodiment a substantially rectangular aperture, which has the same shape as the support platform 111 of the respective workpiece support element 109 and is such that the support platform 111 projects therethrough, and a plurality of spring elements 135 which are disposed about the periphery of the aperture 131 such as to engage a workpiece 105, in this embodiment four spring elements 135 which are configured to engage a workpiece 105 at the respective corners thereof, such as to provide for the automatic positioning of a workpiece 105 when loaded onto the workpiece support element 109.

In this embodiment the spring elements 135 each comprise a spring contact 137, here in the form of an upstanding stud, which includes a workpiece-contact face 139, here an outwardly-facing arcuate face, which laterally engages a counterpart engagement feature 141 of the workpiece 105, here a recess, typically as provided by a through aperture, and a resilient arm 143 which resiliently connects the spring contact 137 to the body of the positioning member 125, such as to bias the spring contact 137, and the workpiece-contact face 139 thereof, outwardly relative to the engagement feature 141 of the workpiece 105, here in a direction substantially along the length of the aperture 131 of the workpiece positioning element 129, and hence along the length of the supported workpiece 105.

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In this embodiment the resilient arms 143 are substantially linear arms which extend substantially parallel to one opposite pair of sides, here the shorter sides, of the aperture 131 from a central region of the respective sides.

In this embodiment the positioning member 125 further includes a plurality of tool-receiving apertures 145, which are disposed adjacent and to the outer side of each of the resilient arms 143 and are configured to receive tooling which is operative to deflect the spring elements 135 in order to effect the loading and unloading of workpieces 105 into and from the respective workpiece support element 109 when using a workpiece loading/unloading mechanism.

With this configuration, the spring elements 135 are deflectable inwardly relative to the aperture 131 of the respective workpiece positioning element 129 by tooling to allow for the loading of a workpiece 105 into the workpiece positioning element 129, and, on removal of the tooling, the resilience of the resilient arms 143 acts to bias the spring contacts 137 outwardly, such as automatically and individually precisely to position the loaded workpiece 105, without requiring any subsequent positioning operation.

The positioning member 125 further comprises a plurality of, in this embodiment four positioning recesses 146, here through holes, which are disposed at spaced locations therein, in this embodiment at the corner regions of the positioning member 125 in correspondence with the positioning recesses 119 in the support member 107. As will be described in more detail hereinbelow, the positioning recesses 146 are configured to receive positioning elements 206 on a workpiece carrier loading/unloading assembly 203, which is used to load/unload workpieces 105 into and from the workpiece carrier 103, and act to position the positioning member 125 on the workpiece carrier loading/unloading assembly 203.

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The positioning member 125 further comprises a plurality of, in this embodiment four fixing elements 147, in this embodiment clips, here snap clips, which are disposed at spaced locations therein in correspondence to the engagement recesses 121 in the support member 107, and act to engage the engagement recesses 121 in the support member 107, such as to hold together the support member 107 and the positioning member 125 as a unitary structure and also fix the position of the positioning member 125 relative to the support member 107.

In this embodiment the use of fixing elements 147 as the means of fixing together the components of the workpiece carrier 103 advantageously allows for quick and easy assembly and dis-assembly, in the event that modification or repair is required. In other embodiments, other means of fixing could be employed, such as adhesive bonding, spot-welding and riveting.

In this embodiment the spring elements 135 are precision formed, typically by laser cutting or chemical milling, such as to have a precise and predetermined spatial arrangement, and also to ensure that the spring force of the spring elements 135 is matched, such as to ensure that the workpieces 105 are precisely positioned.

In this embodiment the sheet body of the positioning member 125 is formed of a spring steel, but could be formed of any other material which provides the spring elements 135 with the necessary characteristics which provide for the repeated accurate positioning of the supported workpieces 105.

The positioning member 125 further comprises at least two fiducials 149, which enable the alignment of the workpiece carrier 103 when mounted in a machine. As the workpieces 105 which are mounted in the workpiece carrier 103 are automatically and individually pre-positioned by the respective workpiece positioning elements 129, it is only necessary to align the workpiece carrier 103.

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In one embodiment workpieces 105 can be manually loaded and unloaded into and from the workpiece support elements 109. In this manual operation, the engagement features 141 at one of the ends of a workpiece 105 are engaged on the counterpart contact elements 137 of the spring elements 135, and the workpiece 105 is biased manually against the biasing force of the spring elements 135 at the one end of the workpiece 105 and the engagement features 141 at the other end of the workpiece 105 are engaged on the counterpart contact elements 137 of the spring elements 135 at the other end of the workpiece 105.

In another, preferred embodiment loading and unloading of workpieces 105 is achieved using a workpiece carrier loading/unloading assembly 203, as will be described hereinbelow with reference to Figures 3 to 5 of the accompanying drawings.

Figure 3 illustrates a workpiece carrier loading/unloading assembly 203 in accordance with a preferred embodiment of the present invention for loading or unloading a plurality of workpieces 105 into and from the workpiece carrier 103.

The workpiece carrier loading/unloading assembly 203 comprises a body unit 205, in this embodiment a box section, here of rectangular shape, a plurality of positioning elements 206 which act to fix the position of a workpiece carrier 103 when mounted on the body unit 205, a plurality of actuator units 207 which are disposed to an upper surface of the body unit 205 in an arrangement corresponding to the arrangement of the workpiece support elements 109 of the workpiece carrier 103, in this embodiment four actuator units 207 in parallel, side-by-side relation, and are operable to allow for loading and unloading of workpieces 105 into the workpiece support elements 109 of the workpiece carrier 103 in loading and unloading operations, as will be described in more detail hereinbelow.

The actuator units 207 each comprise at least one, in this embodiment a plurality of upstanding actuator pins 211, here four actuator pins 211, which

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are arranged in correspondence with the tool-receiving apertures 145 adjacent the resilient arms 143 of the spring elements 135 of a respective one of the workpiece support elements 109 of the workpiece carrier 103, such that, when the workpiece carrier 103 is mounted on the body unit 205, the actuator pins 211 extend into respective ones of the tool-receiving apertures 145. In this embodiment the actuator pins 211 have a length which is such as to extend to a height just below the surface of the support platforms 111, such as to prevent the actuator pins 211 from impinging on the supported workpieces 105.

The actuator pins 211 each comprise a body section 213 which is rotatably coupled to the body unit 205, in this embodiment about a vertical axis, and an actuator section 215, in this embodiment a flat blade, which is configured to extend into the tool-receiving aperture 145 adjacent the resilient arm 143 of the respective spring element 135. As will be described in more detail hereinbelow, the actuator pins 211 are rotatable between a first, rest configuration, as illustrated in Figure 5(a), in which the workpiece carrier 103 can be mounted onto the body unit 205, and a second, actuated configuration, as illustrated in Figure 5(c), in which the actuator sections 215 of the actuator pins 211 engage the resilient arms 143 of the respective spring elements 135 and bias the spring contacts 137 inwardly to allow for the loading and unloading of workpieces 105 to and from the workpiece support elements 109.

The workpiece carrier loading/unloading assembly 203 further comprises an actuator member 221, in this embodiment a lever, which is operatively coupled to each of the actuator pins 211, in this embodiment by a linkage assembly (not illustrated), between a first, rest position, in which the actuator pins 211 are in the rest configuration to allow for the loading and unloading of the workpiece carrier 203 to and from the body unit 205 and an actuated position, in which the actuator pins 211 are rotated to the actuated configuration in which the actuator sections 215 of the actuator pins 211 engage the resilient arms 143 of the respective spring elements 135 and

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bias the spring contacts 137 inwardly to allow for the loading and unloading of workpieces 105 to and from the workpiece support elements 109.

Operation of the workpiece carrier loading/unloading assembly 203 is illustrated in Figures 5 of the accompanying drawings.

First, as illustrated in Figures 5(a) to (f), workpieces 105 are loaded onto the workpiece carrier 103.

In a first loading step, as illustrated in Figure 5(a), a workpiece carrier 103 is disposed over the workpiece carrier loading/unloading assembly 203.

In a second loading step, as illustrated in Figure 5(b), with the actuator member 221 of the workpiece carrier loading/unloading assembly 203 de-actuated, in this embodiment in the rest position, the workpiece carrier 103 is loaded onto the workpiece carrier loading/unloading assembly 203, which causes the actuator pins 211 of each of the actuator units 207 to pass into the tooling apertures 145 adjacent the resilient arms 143 of the spring elements 135. It is to be understood that loading of the workpiece carrier loading/unloading assembly 203 can be achieved by fixing the position of the workpiece carrier 103 and raising the workpiece carrier loading/unloading assembly 203, fixing the position of the workpiece carrier loading/unloading assembly 203 and lowering the workpiece carrier 103 or both raising the workpiece carrier loading/unloading assembly 203 and lowering the workpiece carrier 103.

In a third loading step, as illustrated in Figure 5(c), the actuator member 221 of the workpiece carrier loading/unloading assembly 203 is actuated, in this embodiment by moving the same to the actuated position, which causes the actuator sections 215 of the actuator pins 211 to engage the resilient arms 143 of the respective spring elements 135 and bias the spring contacts 137 inwardly to allow for the loading of workpieces 105 into the workpiece support elements 109.

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In a fourth loading step, as illustrated in Figure 5(d), workpieces 105 are loaded into the workpiece support elements 109 as required, with the engagement features 141 on the workpieces 105 being located on counterpart ones of the spring contacts 137 of the spring elements 135. For ease of understanding, part of the illustrated workpiece 105 is shown in phantom.

In a fifth loading step, as illustrated in Figure 5(e), the actuator member 221 of the workpiece carrier loading/unloading assembly 203 is de-actuated, in this embodiment by returning the same to the rest position, which causes the spring elements 135 of each of the workpiece positioning elements 129 gradually to return outwardly, in this embodiment through dis-engagement of the actuator sections 215 of the actuator pins 211 from the resilient arms 143 of the spring elements 135, until such point that the actuator pins 211 of each of the workpiece locating units 207 are dis-engaged from the spring elements 135 of the respective workpiece positioning elements 129 and the workpieces 105 are laterally outwardly biased, in this embodiment along the length thereof, by the spring contacts 137 under the bias of the resilient arms 143 of the spring elements 135. When so biased, the workpieces 105 are both positioned accurately in the workpiece carrier 103 and also rendered flat on the support platforms 111 of the respective workpiece support elements 109. As described hereinabove, as a result of matching the spring force of the spring contacts 135, the workpieces 105 are automatically positioned in the desired position, such that no post-positioning operations are necessary.

In a final step, as illustrated in Figure 5(f), the workpiece carrier 103 is removed from the workpiece carrier loading/unloading assembly 203.

Following this loading operation, the workpiece carrier 103 having the workpieces 105 loaded thereon is ready for operation in a machine, either *in situ* or *ex situ*, and the machine operation requires a single alignment operation of the workpiece carrier 103, through use of the fiducials 149, and no individual alignment of each of the respective workpieces 105.

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Following operation in the machine, an unloading operation, as illustrated in Figures 5(g) to (l) is performed in order to unload the workpieces 105 from the workpiece carrier 103.

In a first unloading step, as illustrated in Figure 5(g), the workpiece carrier 103 is disposed over the workpiece carrier loading/unloading assembly 203.

In a second unloading step, as illustrated in Figure 5(h), with the actuator member 221 of the workpiece carrier loading/unloading assembly 203 de-actuated, in this embodiment in the rest position, the workpiece carrier 103 is located on the workpiece carrier loading/unloading assembly 203, which causes the actuator pins 211 of each of the actuator units 207 to pass into the tooling apertures 145 adjacent the resilient arms 143 of the spring elements 135 of the respective workpiece positioning elements 129. It is to be understood that loading of the workpiece carrier loading/unloading assembly 203 can be achieved by fixing the position of the workpiece carrier 103 and raising the workpiece carrier loading/unloading assembly 203, fixing the position of the workpiece carrier loading/unloading assembly 203 and lowering the workpiece carrier 103 or both raising the workpiece carrier loading/unloading assembly 203 and lowering the workpiece carrier 103.

In a third unloading step, as illustrated in Figure 5(i), the actuator member 221 of the workpiece carrier loading/unloading assembly 203 is actuated, in this embodiment by moving the same to the actuated position, which causes the actuator sections 215 of the actuator pins 211 to engage the resilient arms 143 of the respective spring elements 135 and bias the spring contacts 137 inwardly to allow for the unloading of workpieces 105 from the workpiece support elements 109.

In a fourth unloading step, as illustrated in Figure 5(j), workpieces 105 are unloaded from the workpiece carrier 103.

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In a fifth unloading step, as illustrated in Figure 5(k), the actuator member 221 of the workpiece carrier loading/unloading assembly 203 is de-actuated, in this embodiment by returning the same to the rest position, which causes the spring elements 135 of each of the workpiece positioning elements 129 gradually to return outwardly, in this embodiment through dis-engagement of the actuator sections 215 of the actuator pins 211 from the resilient arms 143 of the spring elements 135, until such point that the actuator pins 211 of each of the workpiece locating units 207 are dis-engaged from the spring elements 135 of the respective workpiece positioning elements 129 and the spring elements 135 are in the rest configuration.

In a final step, as illustrated in Figure 5(l), the workpiece carrier 103 is removed from the workpiece carrier loading/unloading assembly 203.

Figure 6 illustrates one modified positioning member 125 for the workpiece carrier 103 of the above-described embodiment.

In this embodiment the resilient arms 143 are inclined to the respective opposite sides of the aperture 131 such as to apply a tensive force through a central region of a supported workpiece 105, and preferably through the center of the supported workpiece 105. In this embodiment, by providing for tension components in two axes, flatness of the supported workpiece 105 is promoted.

Figure 7 illustrates another modified positioning member 125 for the workpiece carrier 103 of the above-described embodiment.

In this embodiment the resilient arms 143 are arcuate elements which are such as to apply a tensive force through a central region of a supported workpiece 105, and preferably through the center of the supported workpiece 105. Again, in this embodiment, by providing for tension components in two axes, flatness of the supported workpiece 105 is promoted.

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Finally, it will be understood that the present invention has been described in its preferred embodiments and can be modified in many different ways without departing from the scope of the invention as defined by the appended claims.

For example, in one modification, the workpiece loading/unloading assembly 203 can include a plurality of actuator members 221, such that each actuator member 221 operates a limited number of actuator units 207, in one embodiment one actuator member 221 for each actuator unit 207.

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CLAIMS

1. A workpiece carrier for supporting a plurality of workpieces, preferably flexible workpieces, the workpiece carrier comprising:
a plurality of workpiece supports, each for supporting a workpiece; and
a plurality of workpiece positioners, each associated with a respective one of the workpiece supports and being operative to position a workpiece at a predetermined position in the respective workpiece support, wherein the workpiece positioners each comprise a plurality of biasing elements which are disposed in opposed relation and configured laterally outwardly to bias the workpiece to tension the workpiece and position the workpiece at the predetermined position.

2. The workpiece carrier of claim 1, wherein the workpiece positioners are each configured automatically to position a workpiece at the predetermined position in the respective workpiece support when loaded thereinto, without requiring any subsequent positioning operations.

3. The workpiece carrier of claim 1 or 2, wherein the workpiece positioners are each configured such that workpieces are repeatedly positioned at the predetermined position when loaded into the respective workpiece support.

4. The workpiece carrier of any of claims 1 to 3, wherein the workpiece supports each include a support platform for supporting a workpiece over the surface thereof.

5. The workpiece carrier of any of claims 1 to 4, wherein the biasing elements are configured laterally to engage respective engagement features of a workpiece and apply an outwardly-directed biasing force thereto.

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6. The workpiece carrier of claim 5, wherein the engagement features comprise recesses.

7. The workpiece carrier of claim 5, wherein the engagement features comprise through apertures.

8. The workpiece carrier of any of claims 1 to 7, wherein the workpiece positioners each comprise first and second pairs of biasing elements.

9. The workpiece carrier of any of claims 1 to 8, wherein the biasing elements have matched biasing forces.

10. The workpiece carrier of any of claims 1 to 9, wherein the biasing elements comprise spring elements.

11. The workpiece carrier of claim 10, wherein the spring elements each comprise a spring contact for engaging an engagement feature of a workpiece when supported on the respective workpiece support, and a spring arm which is deflectable inwardly and operative resiliently to bias the spring contact laterally outwardly.

12. The workpiece carrier of claim 11, wherein the spring contact has an arcuate workpiece-contact face.

13. The workpiece carrier of claim 11 or 12, wherein the spring arm is operative to bias the spring contact laterally outwardly.

14. The workpiece carrier of any of claims 11 to 13, wherein the spring arm is substantially linear.

15. The workpiece carrier of claim 14, wherein the workpieces are substantially rectangular, and the spring arms are configured to extend substantially parallel to one opposite pair of sides of the respective workpiece.

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16. The workpiece carrier of claim 14, wherein the workpieces are substantially rectangular, and the spring arms are inclined to one opposite pair of sides of the respective workpiece.

17. The workpiece carrier of any of claims 11 to 13, wherein the spring arm is arcuate.

18. The workpiece carrier of any of claims 1 to 17, wherein the spring elements are configured to apply a tensive force with force components along a single axis.

19. The workpiece carrier of any of claims 1 to 17, wherein the spring elements are configured to apply a tensive force with force components through a central region of the respective workpiece.

20. The workpiece carrier of claim 19, wherein the spring elements are configured to apply a tensive force with force components through substantially the center of the respective workpiece.

21. The workpiece carrier of any of claims 1 to 20, comprising:
a support member which provides the workpiece supports.

22. The workpiece carrier of claim 21, wherein the support member comprises a plate member.

23. The workpiece carrier of any of claims 1 to 22, comprising:
a positioning member which provides the workpiece positioners.

24. The workpiece carrier of claim 23, wherein the positioning member comprises a sheet body which defines the workpiece positioners.

25. The workpiece carrier of claim 24, wherein the sheet body is of spring steel.

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26. A workpiece carrier loading/unloading system, comprising:
a workpiece carrier for supporting a plurality of workpieces, preferably flexible workpieces, the workpiece carrier comprising: a plurality of workpiece supports, each for supporting a workpiece; and a plurality of workpiece positioners, each associated with a respective one of the workpiece supports and being operative to position a workpiece at a predetermined position in the respective workpiece support, wherein the workpiece positioners each comprise a plurality of biasing elements which are disposed in opposed relation and configured laterally outwardly to bias the workpiece to tension the workpiece and position the workpiece at the predetermined position; and
a workpiece loading/unloading assembly for loading and unloading workpieces into and from the workpiece supports of the workpiece carrier.

27. The system of claim 26, wherein the workpiece carrier loading/unloading assembly comprises a body unit for supporting the workpiece carrier, and a plurality of actuator units, which are disposed to the body unit in an arrangement corresponding to the workpiece supports of the workpiece carrier and are operable to allow for loading and unloading of workpieces into and from the workpiece supports of the workpiece carrier in loading and unloading operations.

28. The system of claim 27, wherein the workpiece carrier loading/unloading assembly comprises a plurality of positioning elements which act to fix the position of the workpiece carrier when mounted on the body unit.

29. The system of claim 27 or 28, wherein the actuator units each comprise a plurality of actuator pins which are operable between a first, actuated position in which the actuator pins engage the biasing elements of the respective workpiece support and configure the biasing elements to allow loading or unloading of a workpiece, and a

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second position in which the biasing elements are configured to tension a workpiece when supported on the workpiece support.

30. The system of claim 29 when appendant upon claim 11, wherein, when the workpiece carrier is mounted on the body unit, the actuator pins are located adjacent the spring arms of the spring elements of the respective workpiece support and operation of the actuator pins to the actuated position acts to deflect the spring arms inwardly.

31. A method of loading workpieces into a workpiece carrier, comprising the steps of:
providing a workpiece carrier for supporting a plurality of workpieces, preferably flexible workpieces, the workpiece carrier comprising: a plurality of workpiece supports, each for supporting a workpiece; and a plurality of workpiece positioners, each associated with a respective one of the workpiece supports and being operative to position a workpiece at a predetermined position in the respective workpiece support, wherein the workpiece positioners each comprise a plurality of biasing elements which are disposed in opposed relation and configured laterally outwardly to bias the workpiece to tension the workpiece and position the workpiece at the predetermined position;
providing a workpiece loading assembly for loading workpieces into the workpiece supports of the workpiece carrier; and
utilizing the workpiece loading assembly to load workpieces into the workpiece supports of the workpiece carrier.

32. The method of claim 31, wherein the workpiece carrier loading assembly comprises a body unit for supporting the workpiece carrier, and a plurality of actuator units, which are disposed to the body unit in an arrangement corresponding to the workpiece supports of the workpiece carrier, and the step of utilizing the workpiece loading assembly comprises the steps of:

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first operating one or more of the actuator units to engage the biasing elements of the respective workpiece positioners and position the same to receive workpieces;
loading workpieces onto the respective workpiece supports; and
second operating the one or more of the actuator units to release the biasing elements of the respective workpiece positioners to tension the supported workpieces.

33. The method of claim 32, wherein the actuator units each comprise a plurality of actuator pins which are operable between a first, actuated position in which the actuator pins engage the biasing elements of the respective workpiece positioner and configure the biasing elements to allow loading of a workpiece and a second, released position in which the biasing elements are configured to tension a workpiece when supported on the workpiece support, the first operating step comprises the step of moving the actuator pins to the actuated position in which the actuator pins engage the biasing elements of the respective workpiece positioner and configure the biasing elements to allow loading of a workpiece, and the second operating step comprises the step of moving the actuator pins to release the biasing elements of the respective workpiece positioner and configure the biasing elements to tension the supported workpiece.

34. The method of claim 33, wherein the biasing elements comprise spring elements, which each comprise a spring contact for engaging an engagement feature of a workpiece when supported on the respective workpiece support, and a spring arm which is deflectable inwardly and operative resiliently to bias the spring contact laterally outwardly, and, when the workpiece carrier is mounted on the body unit, the actuator pins are located adjacent the spring arms of the spring elements of the respective workpiece positioner and operation of the actuator pins to the actuated position acts to deflect the spring elements inwardly.

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35. A method of unloading workpieces from a workpiece carrier, comprising the steps of:
providing a workpiece carrier for supporting a plurality of workpieces, preferably flexible workpieces, the workpiece carrier comprising: a plurality of workpiece supports, each for supporting a workpiece; and a plurality of workpiece positioners, each associated with a respective one of the workpiece supports and being operative to position a workpiece at a predetermined position in the respective workpiece support, wherein the workpiece positioners each comprise a plurality of biasing elements which are disposed in opposed relation and configured laterally outwardly to bias the workpiece to tension the workpiece and position the workpiece at the predetermined position;
providing a workpiece unloading assembly for unloading workpieces from the workpiece supports of the workpiece carrier; and
utilizing the workpiece unloading assembly to unload workpieces from the workpiece supports of the workpiece carrier.

36. The method of claim 35, wherein the workpiece carrier unloading assembly comprises a body unit for supporting the workpiece carrier, and a plurality of actuator units, which are disposed to the body unit in an arrangement corresponding to the workpiece supports of the workpiece carrier, and the step of utilizing the workpiece unloading assembly comprises the steps of:
first operating one or more of the actuator units to engage the biasing elements of the respective workpiece positioners and position the same to release the supported workpieces; and
unloading workpieces from the respective workpiece supports.

37. The method of claim 36, wherein the actuator units each comprise a plurality of actuator pins which are operable between a first, released position and a second, actuated position in which the actuator pins engage the biasing elements of the respective workpiece positioner and configure the biasing elements to allow unloading of a workpiece, and the operating step comprises the step of moving the actuator pins

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to the actuated position in which the actuator pins engage the biasing elements of the respective workpiece positioner and configure the biasing elements to allow unloading of a workpiece.

38. The method of claim 37, wherein the biasing elements comprise spring elements, which each comprise a spring contact for engaging an engagement feature of a workpiece when supported on the respective workpiece support, and a spring arm which is deflectable inwardly and operative resiliently to bias the spring contact laterally outwardly, and, when the workpiece carrier is mounted on the body unit, the actuator pins are located adjacent the spring arms of the spring elements of the respective workpiece positioner and operation of the actuator pins to the actuated position acts to deflect the spring elements inwardly.

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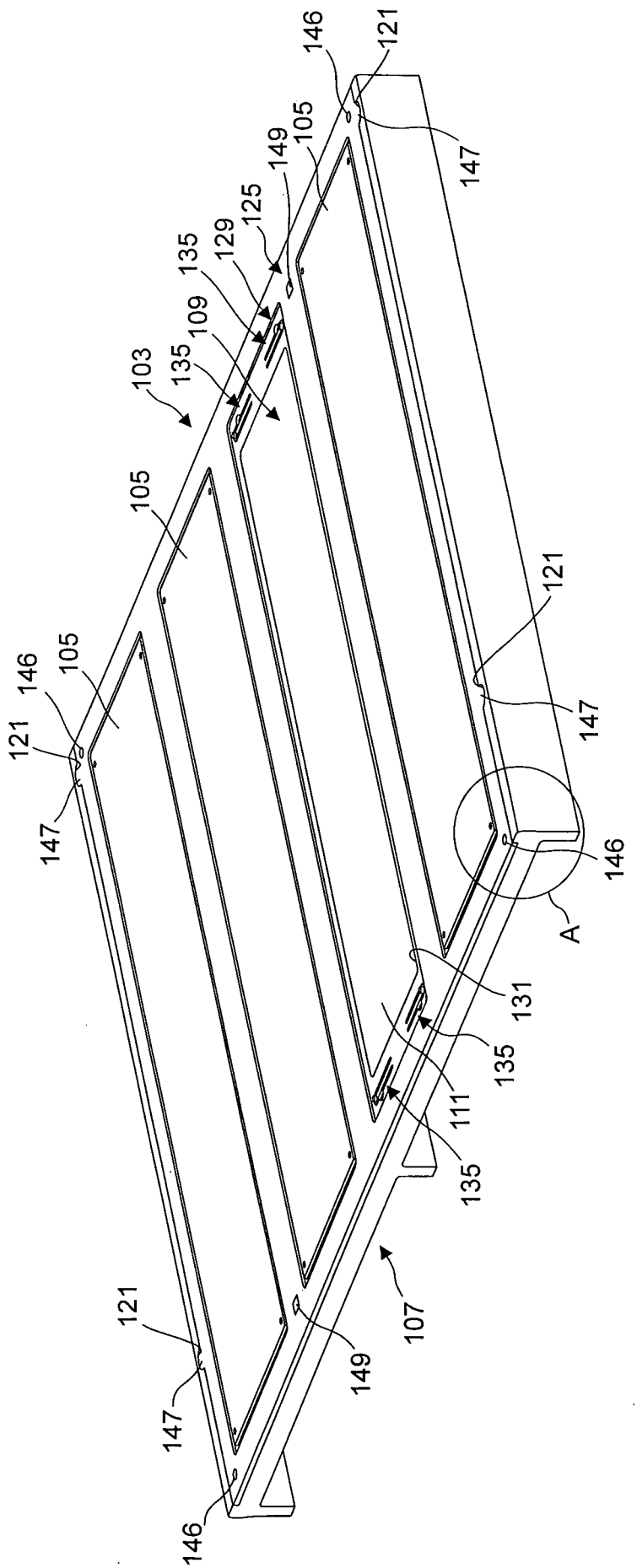


FIG. 1

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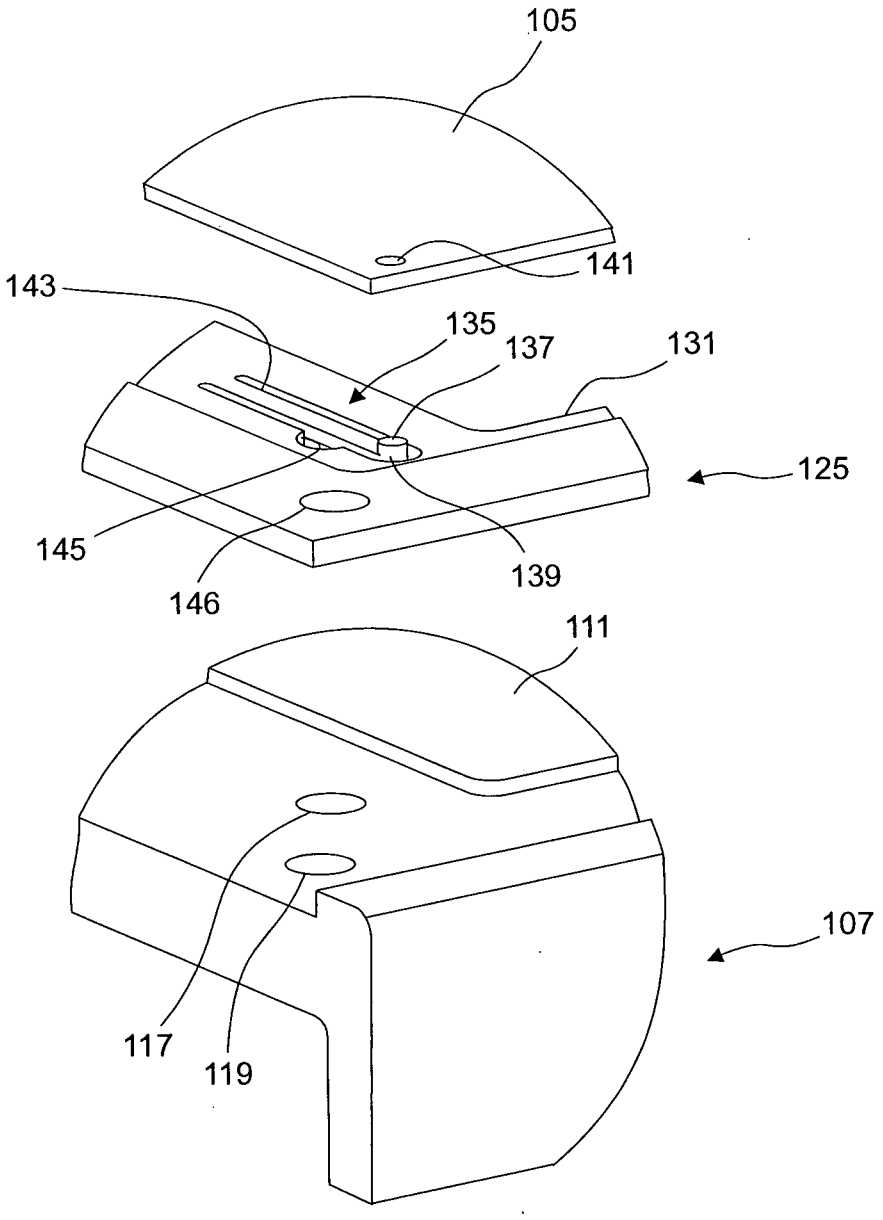


FIG. 2

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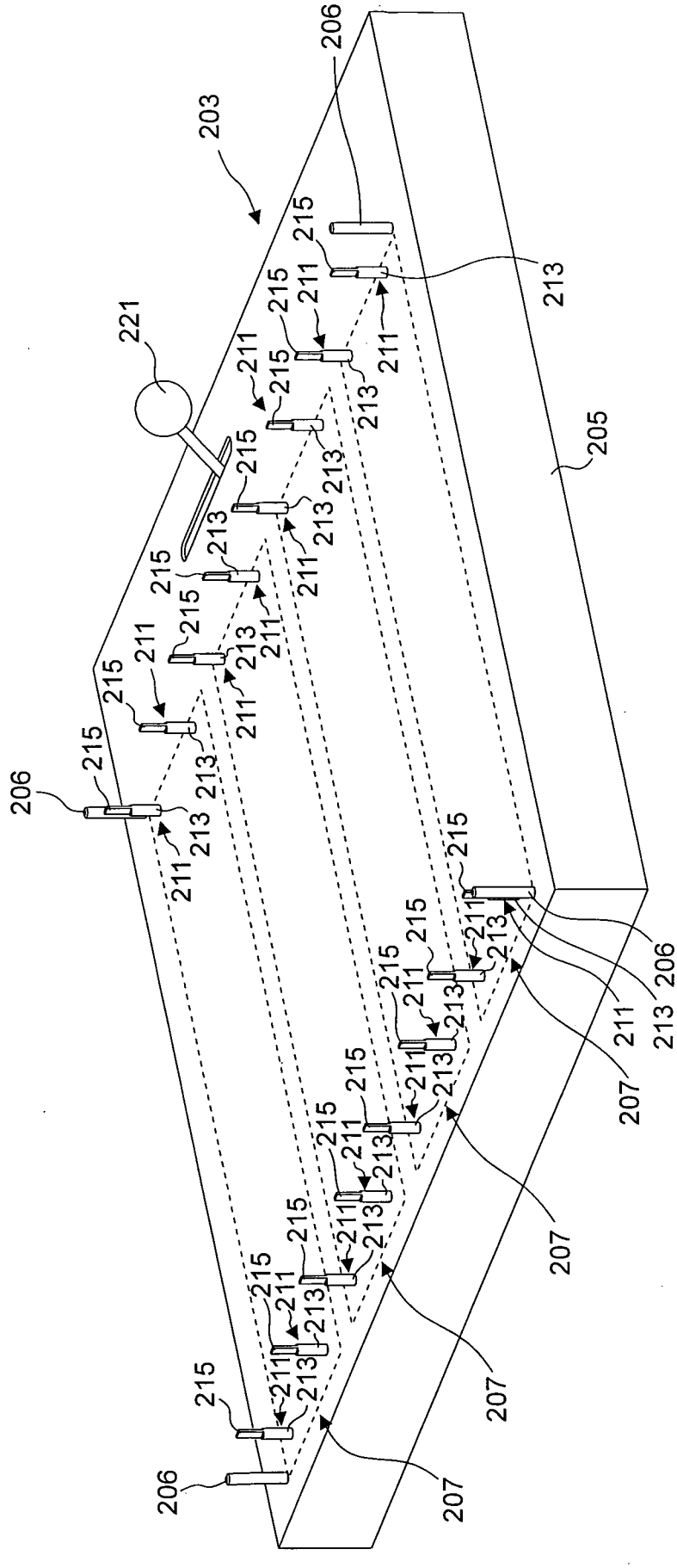


FIG. 3

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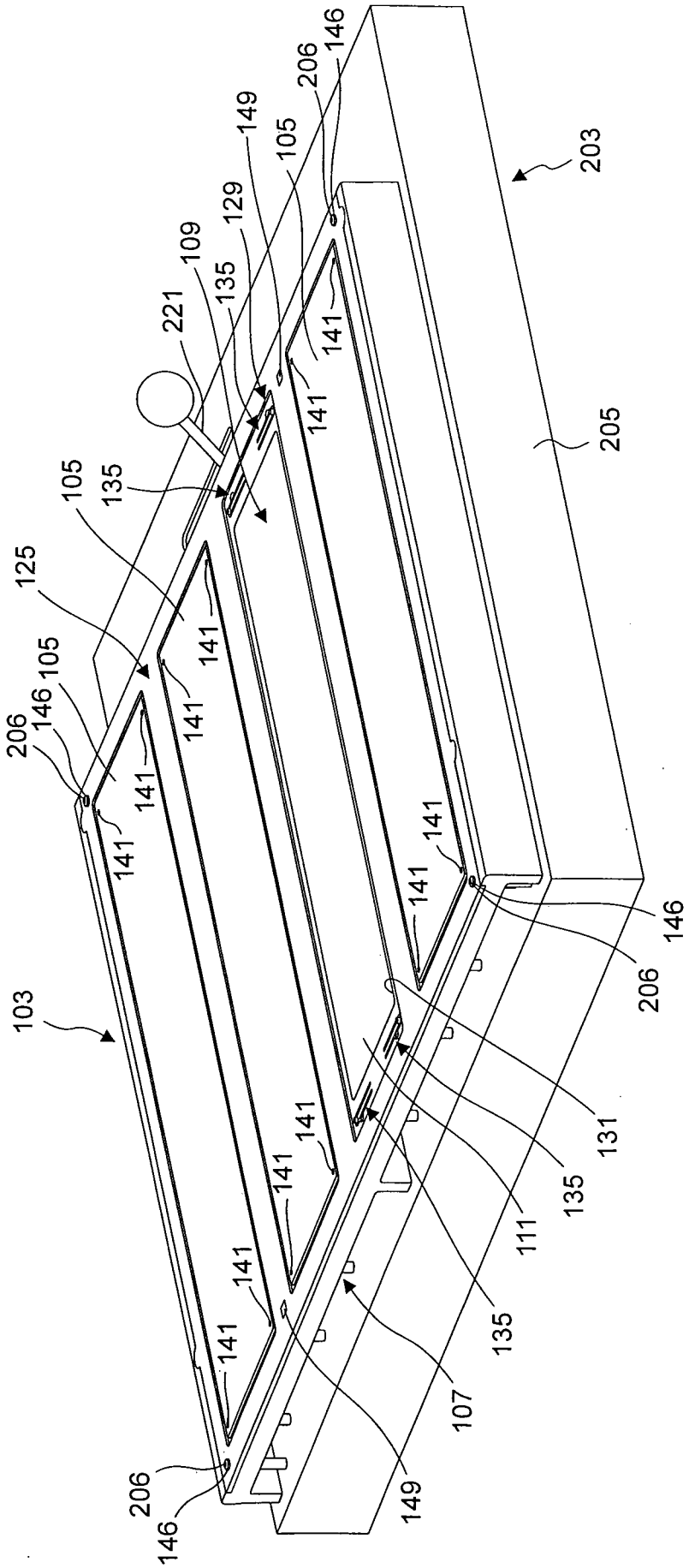


FIG. 4

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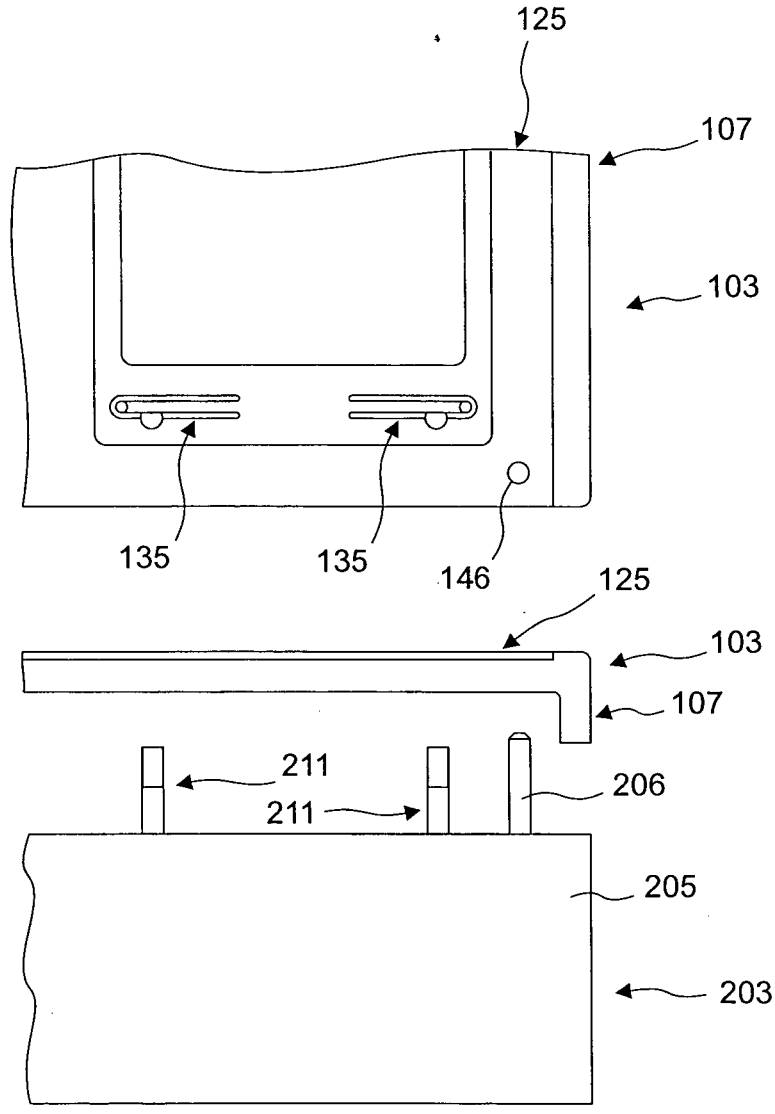


FIG. 5(a)

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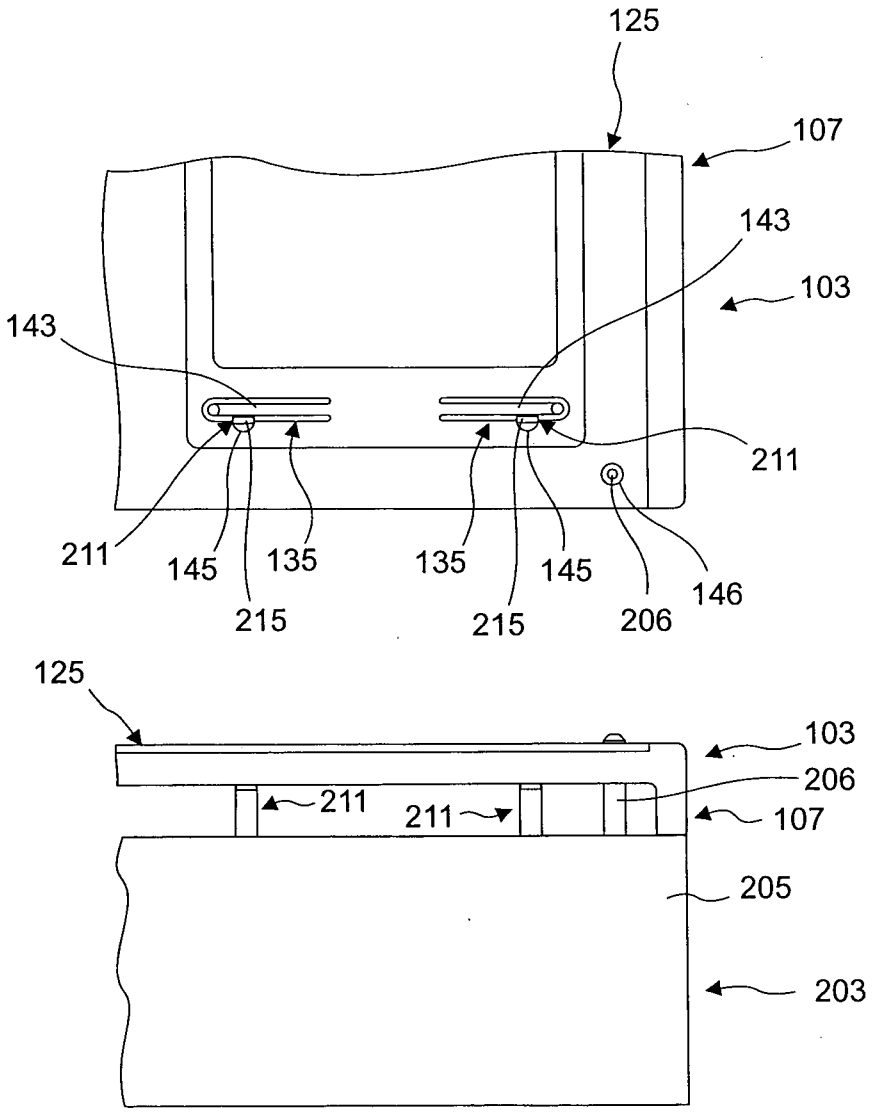


FIG. 5(b)

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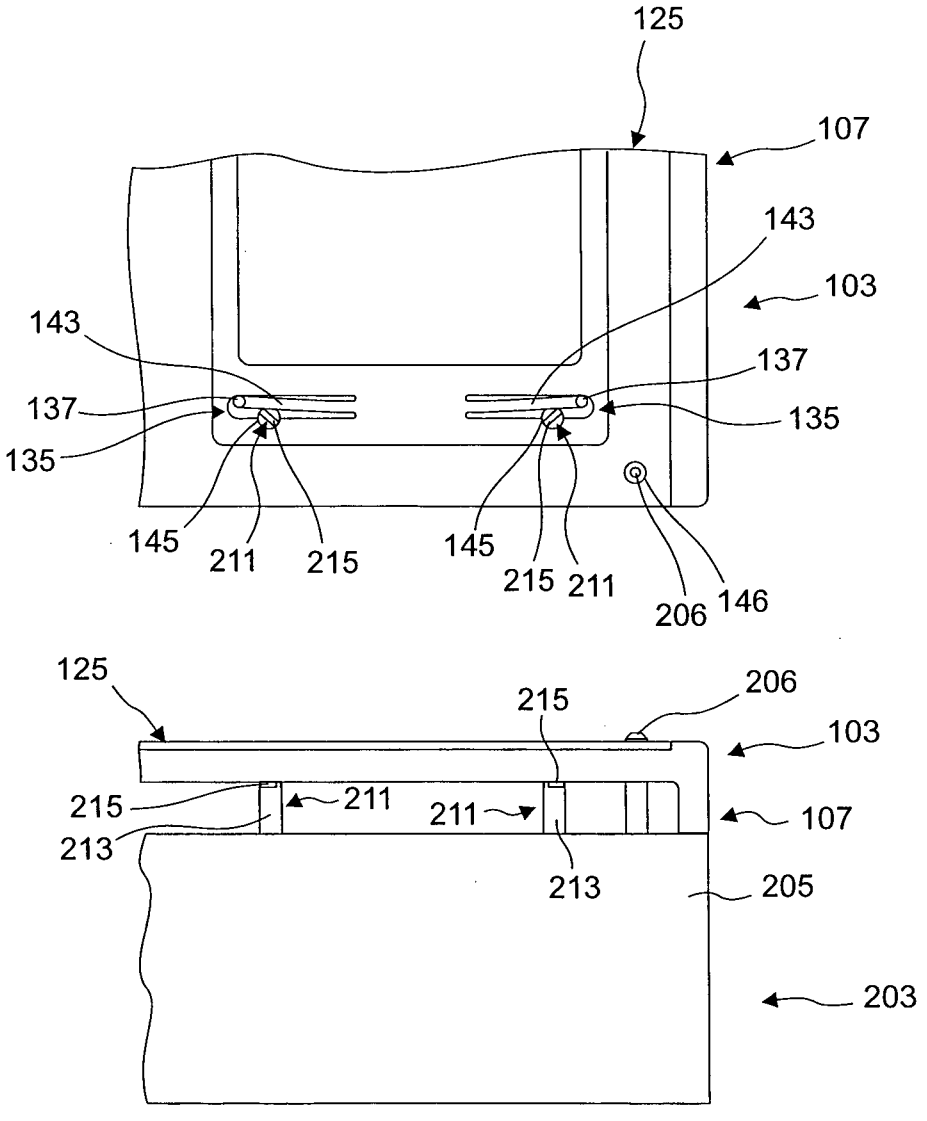


FIG. 5(c)

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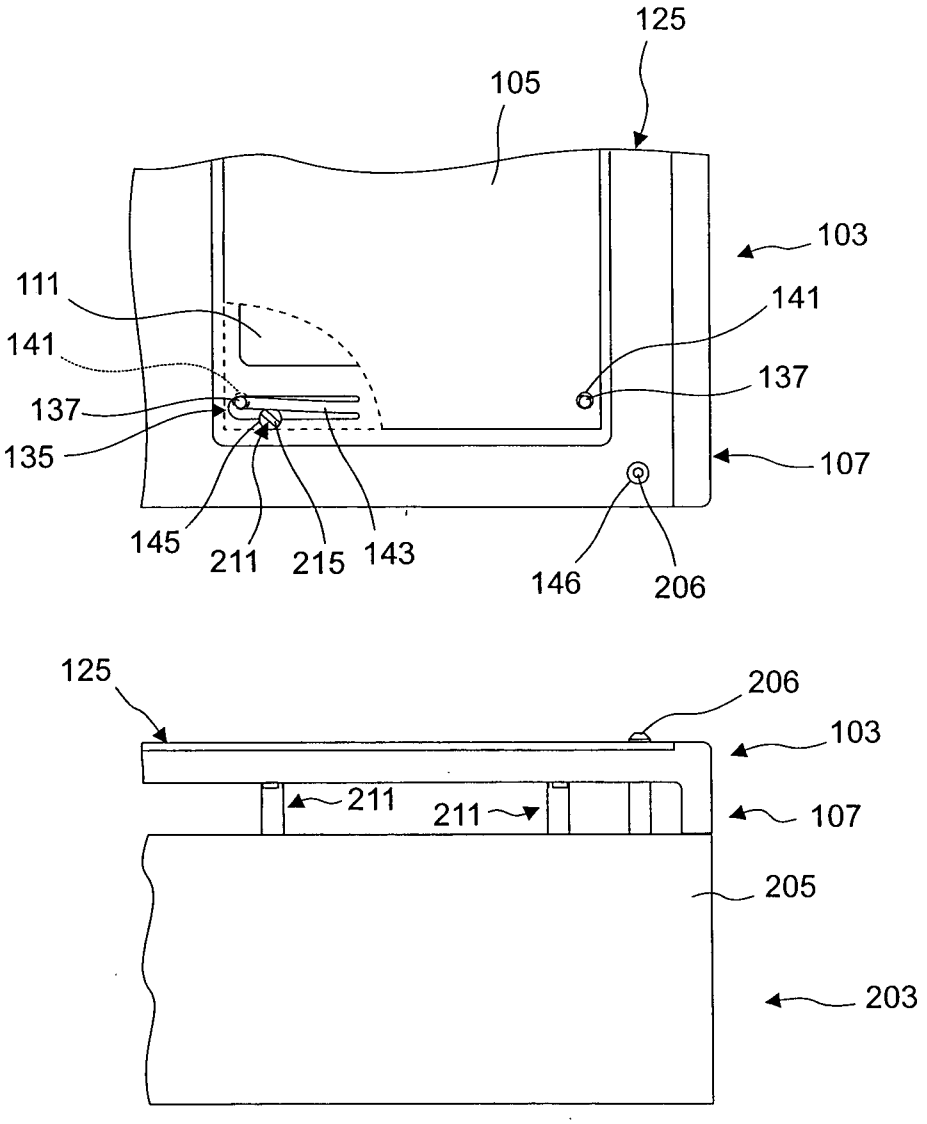


FIG. 5(d)

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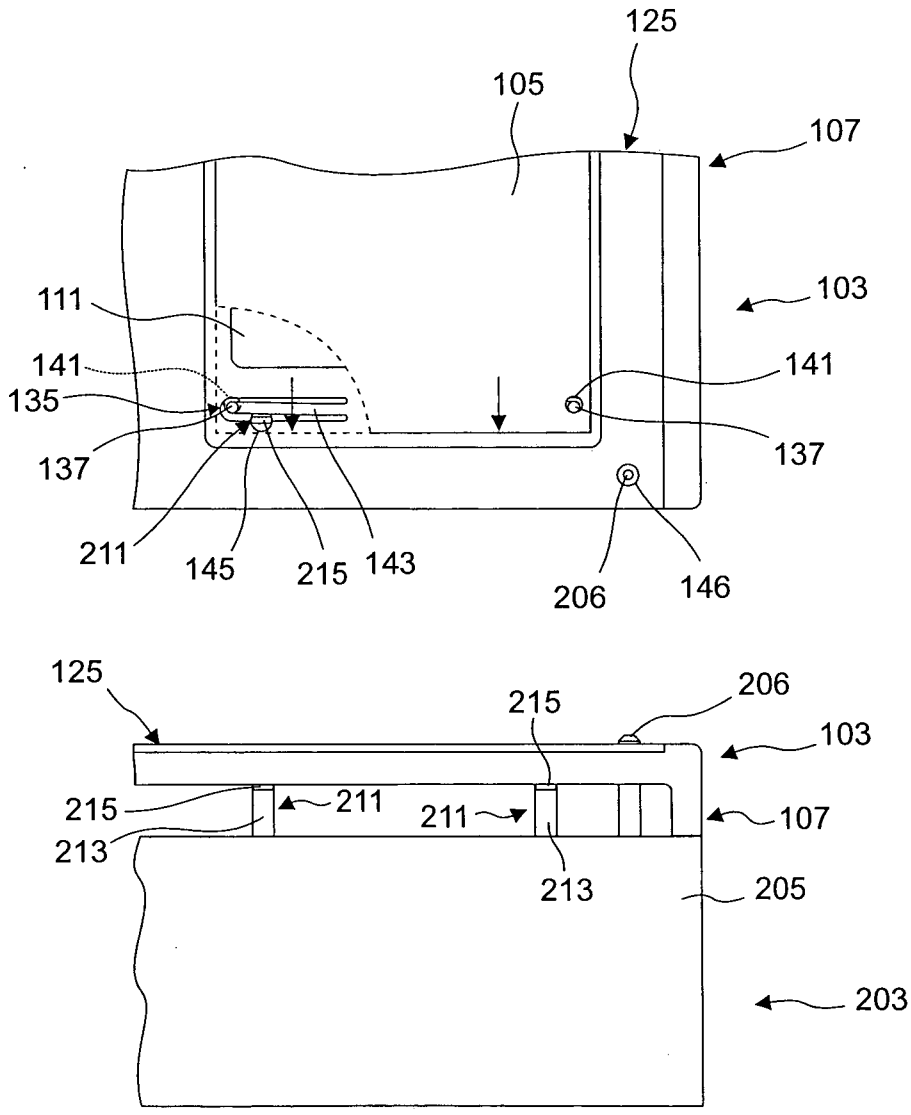


FIG. 5(e)

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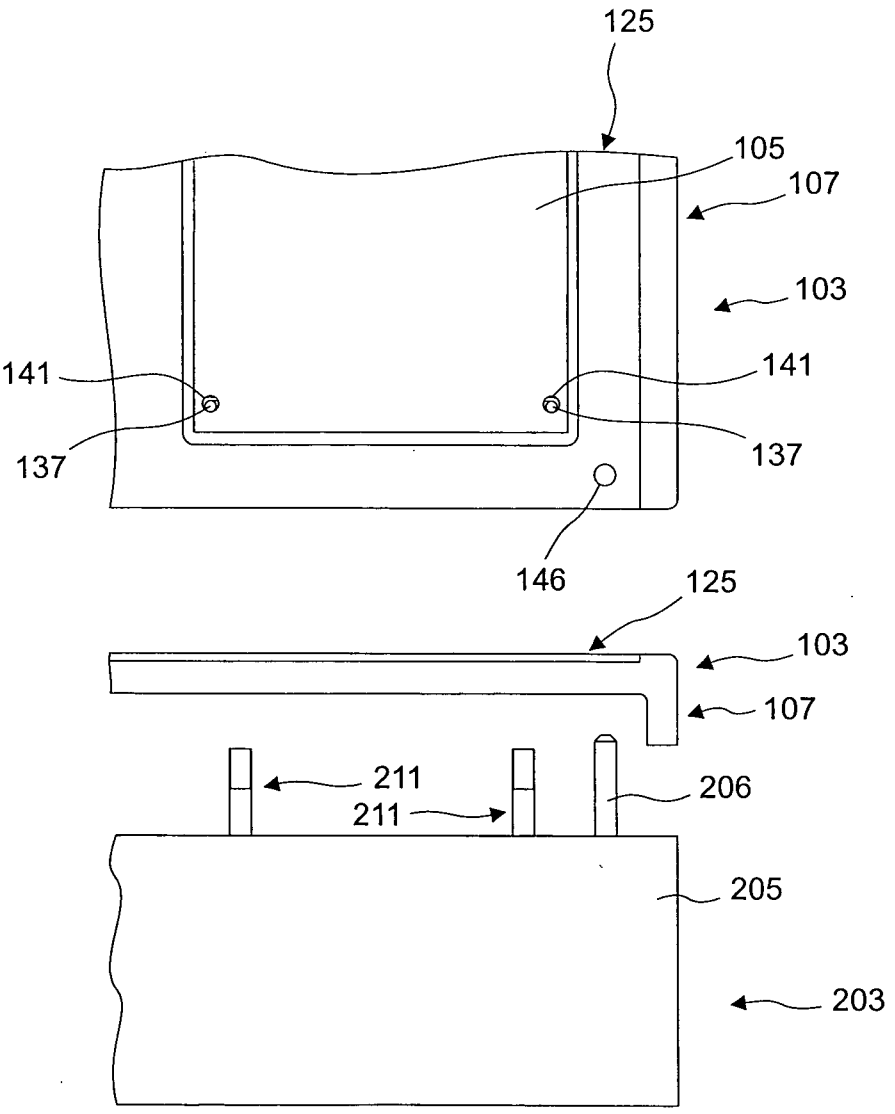


FIG. 5(f)

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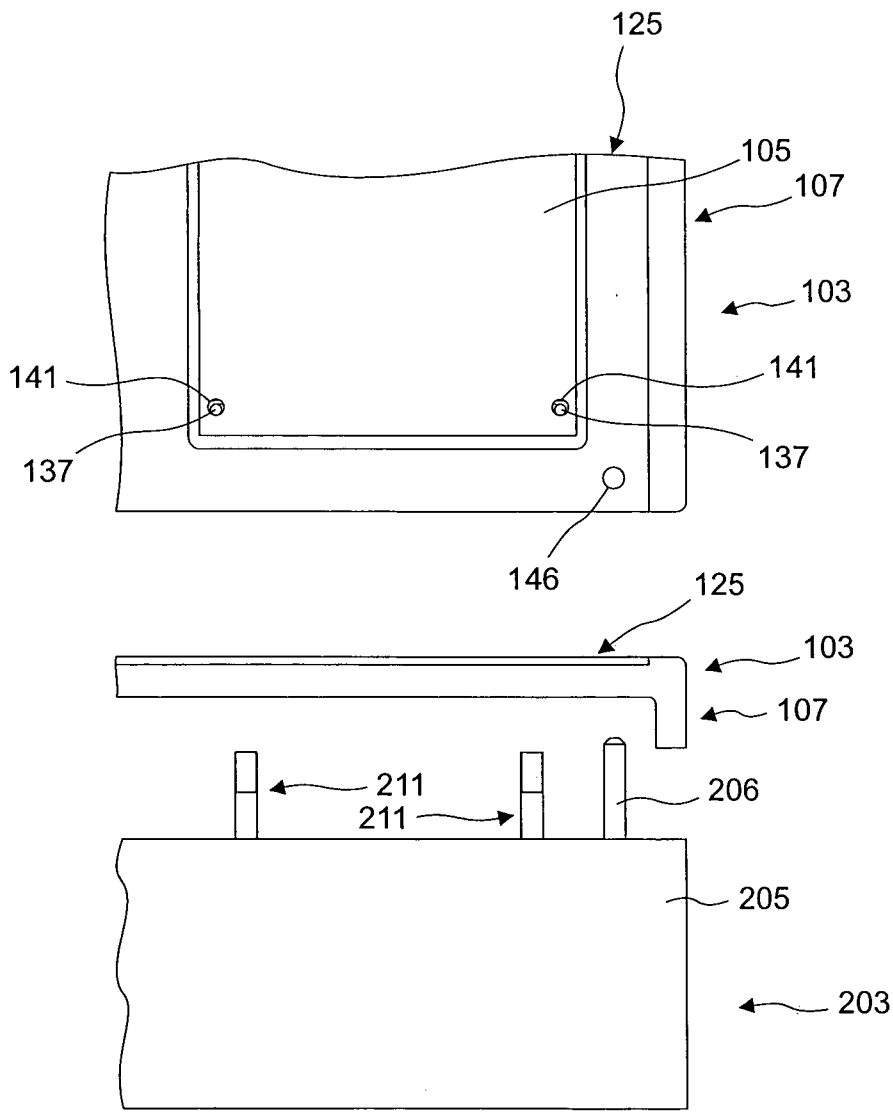


FIG. 5(g)

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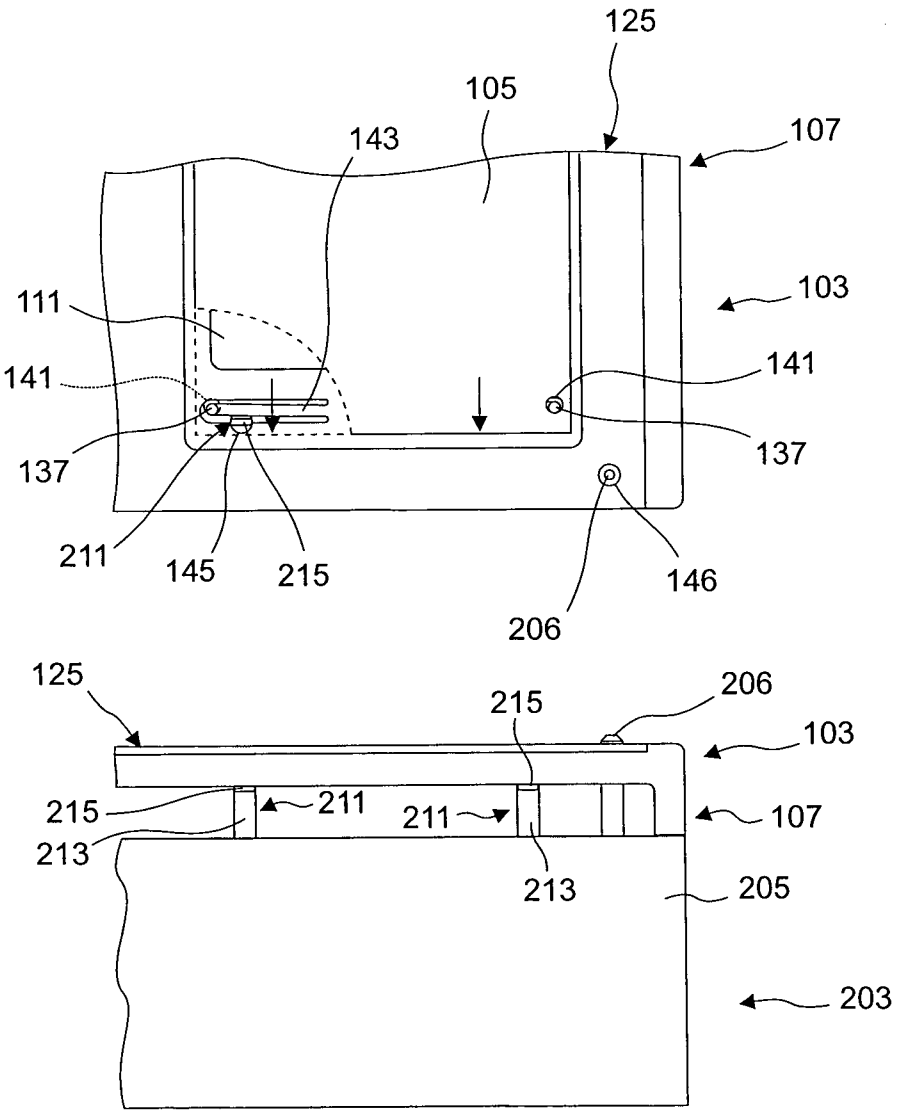


FIG. 5(h)

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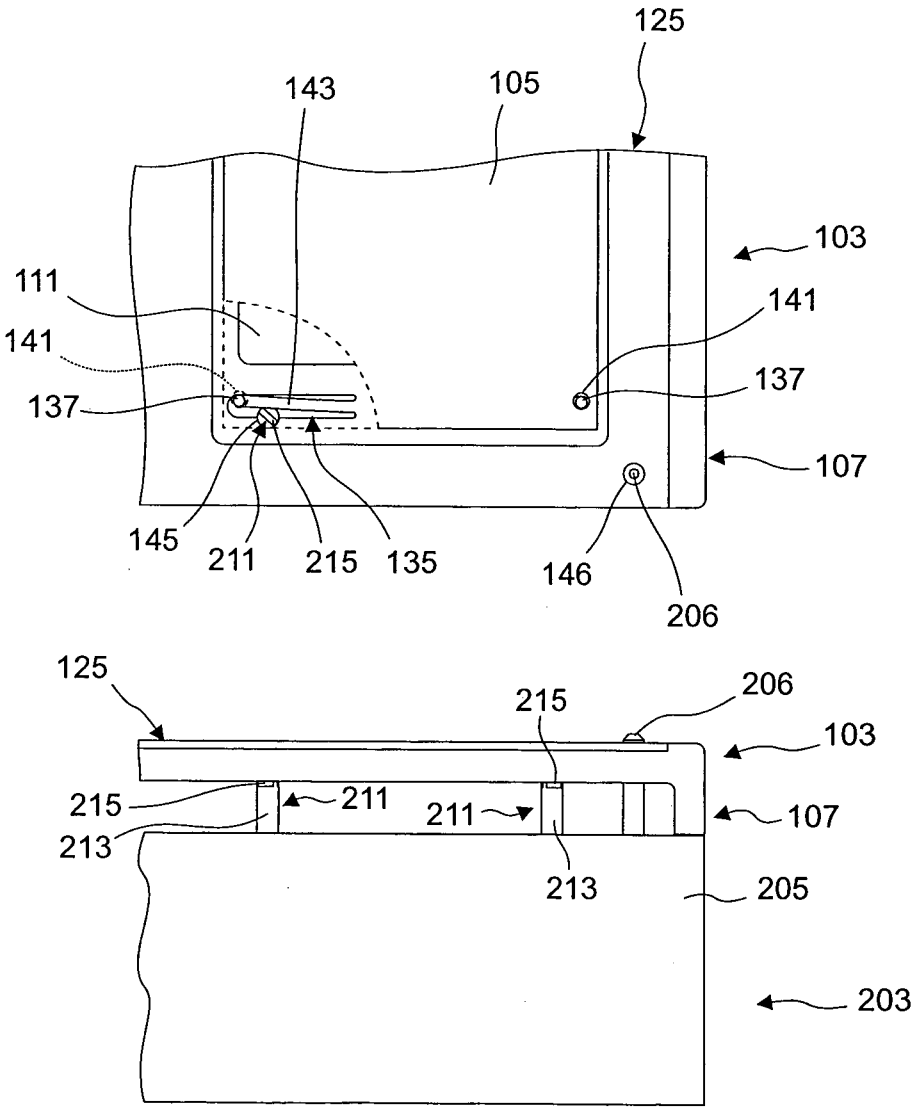


FIG. 5(i)

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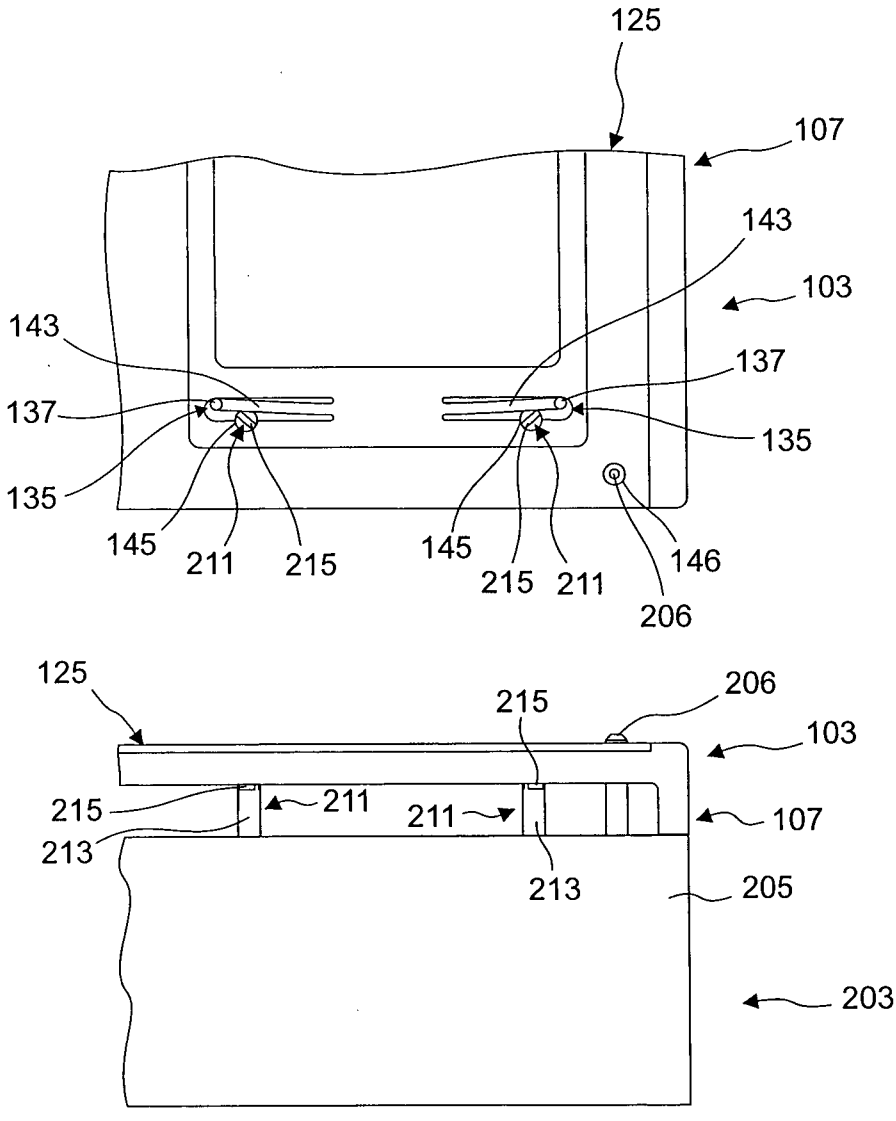


FIG. 5(j)

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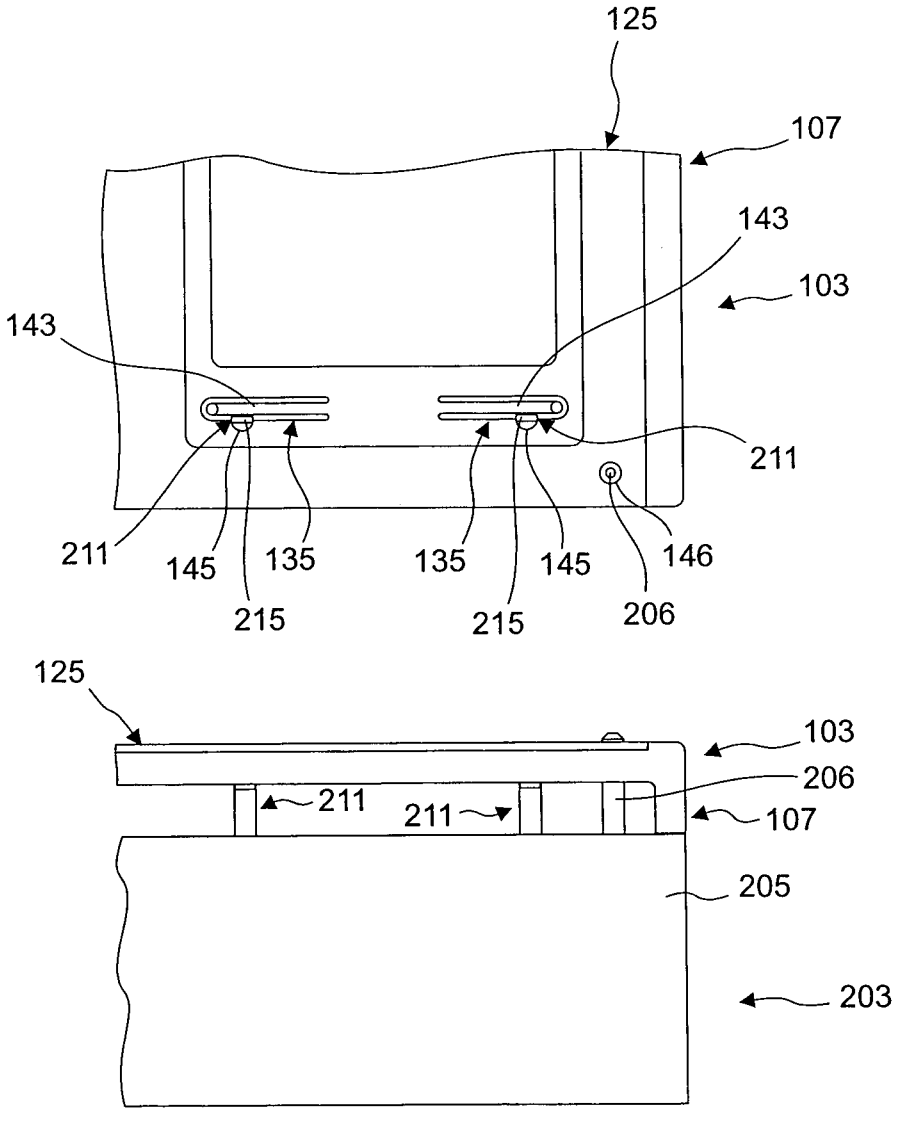


FIG. 5(k)

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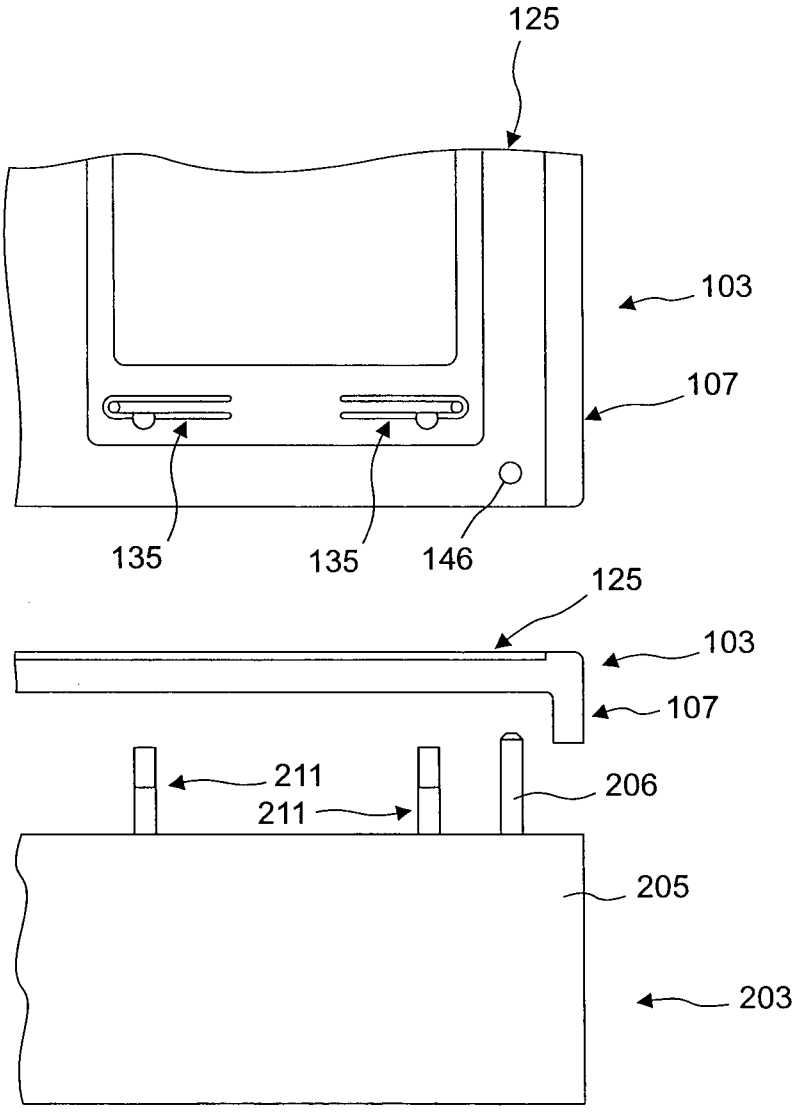


FIG. 5(I)

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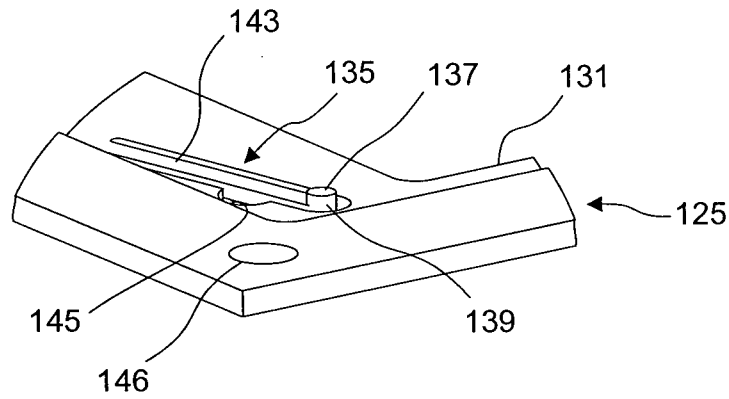


FIG. 6

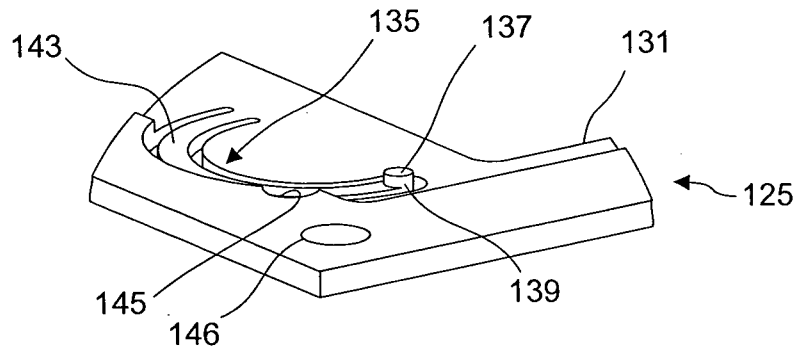


FIG. 7

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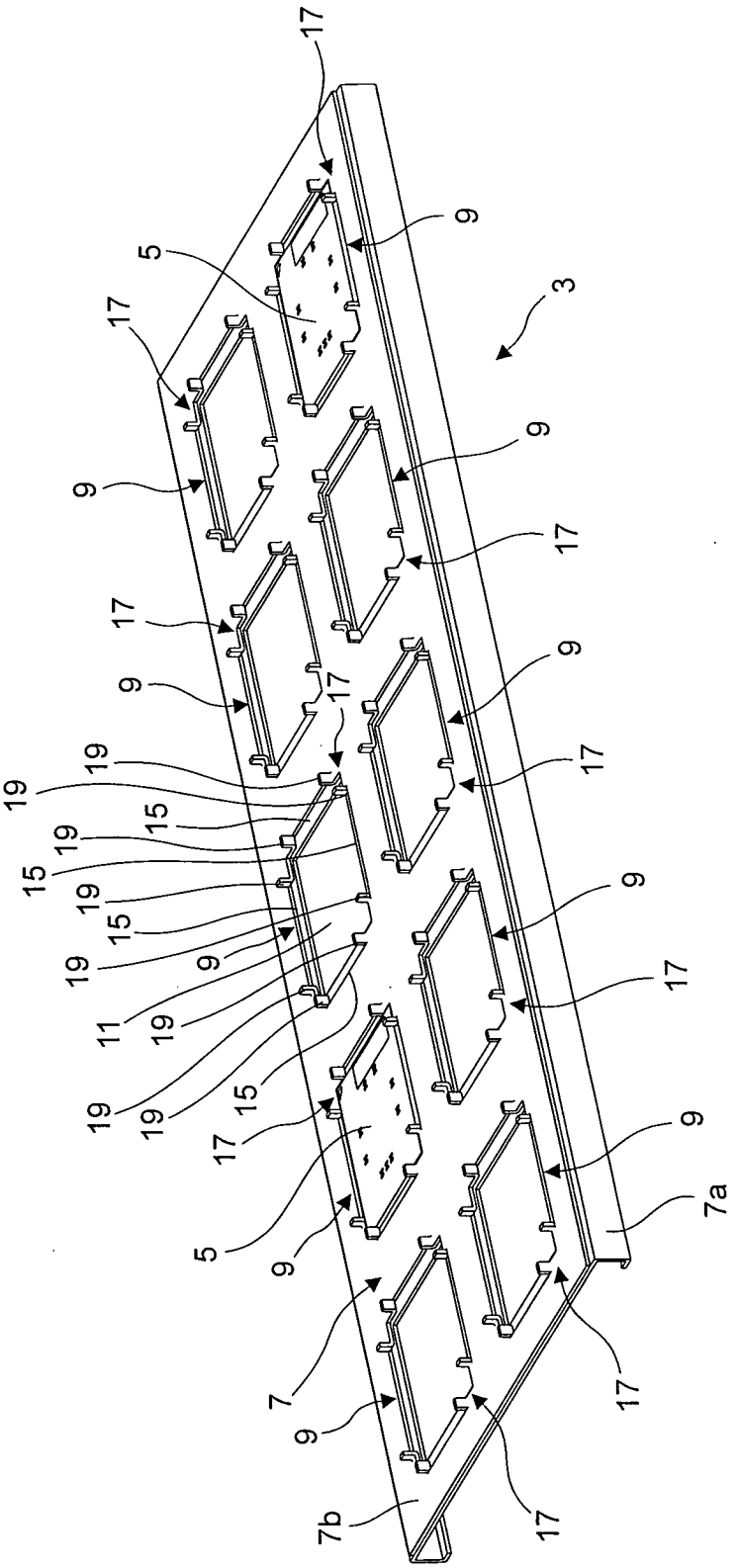


FIG. 8

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INTERNATIONAL SEARCH REPORT

International application No
PCT/GB2008/003808

A. CLASSIFICATION OF SUBJECT MATTER
INV. H05K13/00

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)
H05K B21L B25B

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 practical, search terms used)
EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 6 012 713 A (GLEASON JAMES [US] ET AL) 11 January 2000 (2000-01-11) column 5, line 55 - column 6, line 8; figures 1,5,6	1-38
A	US 2002/158396 A1 (BENNETT RICKY [US] ET AL) 31 October 2002 (2002-10-31) abstract; figure 1	1-38

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

☒ See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

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

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

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

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

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

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

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

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
16 February 2009	27/02/2009

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	Antolí Jover, Jordi

INTERNATIONAL SEARCH REPORT

International application No
PCT/GB2008/003808

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 6012713 A	11-01-2000	NONE	
US 2002158396 A1	31-10-2002	WO 02089551 A1	07-11-2002