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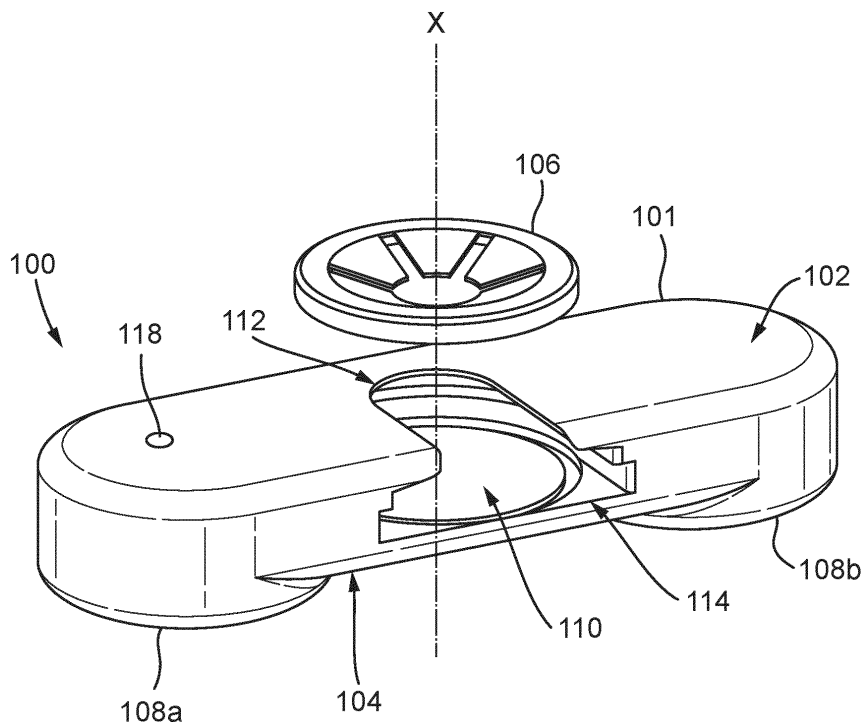
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(54) **CLAMPING DEVICE**

(57) A clamping device (100) for use with a clamp, wherein the clamping device comprises: a body (101) comprising a first side (102) and an opposing second side (104) and a biased member (106), wherein the biased member is configured to receive a foot (326) of the

clamp; and the second side of the body comprising a surface (108b) for applying pressure to a workpiece (324); wherein, in use, the biased member is configured to maintain a constant pressure on the workpiece.



Description

FIELD

[0001] The present invention relates to a clamping device and a related method of using the clamping device to clamp a workpiece.

BACKGROUND

[0002] During manufacture of workpieces or assemblies, it is often necessary to join together components using adhesive. A typical joining process may include depositing adhesive onto each component that is to be joined together, placing the components to be joined together in abutment and applying pressure to the join via a series of clamps. Alternatively, components may be abutted together in a desired form before adhesive is injected between the components. In high value manufacturing operations, the thickness of the adhesive join must be accurately controlled in order to maintain overall tolerances of the assembly. This is particularly important in aerospace applications where assemblies must conform to tightly controlled tolerances. Clamps are typically tightened to a predetermined torque in order to maintain a desired pressure on the components in abutment. If the clamp is applied too tightly, adhesive may bleed out from the join between the components. In addition, clamps which exert too much pressure to a component may damage the component. Alternatively, if the clamp is applied too loosely, there may be too much adhesive between the components leading to voids or weakness in the joint. During the curing process of the adhesive, adhesive may also bleed out from the joint, evaporate or reduce in volumetric size which in turn loosens the pressure exerted by the clamps on the subassembly holding the components in place. Operators may have to re-torque clamps multiple times during a curing process in order to maintain adequate bonding conditions between the components.

SUMMARY

[0003] According to a first aspect of the present invention, there is provided a clamping device for use with a clamp, wherein the clamping device comprises: a body comprising a first side and an opposing second side and wherein the body comprises a biased member, wherein the biased member is configured to receive a foot of the clamp; and the second side of the body comprising a surface for applying pressure to a workpiece; wherein, in use, the biased member is configured to maintain a constant pressure on the workpiece.

[0004] A workpiece may comprise two or more components to be joined together by an adhesive. In use, the biased member may be axially compressed by the foot of the clamp until a desired pressure is achieved on the workpiece. In this way, potential energy is stored in the

biased member. Advantageously, if pressure on the workpiece is subsequently reduced due to adhesive bleeding out from the joint in the workpiece, evaporating or otherwise reducing in volumetric size (thereby decreasing the thickness of the adhesive layer), the biased member may release the stored potential energy and axially expand against the clamp foot and the body of the device thereby maintaining a constant pressure on the workpiece.

[0005] The biased member may be a spring, for example a helical spring, disk spring or leaf spring. Preferably the biased member is a disk spring.

[0006] The biased member may be a component integral with the body of the device. For example, the body may comprise a material configured to exert mechanical spring properties.

[0007] The biased member may comprise a geometry to enable location of the foot of the clamp. In this way, the biased member functions to positively locate the foot of the claim in a central axis defined by the biased member. Such geometries may be configured to enable an interference fit with the foot of the clamp thereby retaining the device to the clamp.

[0008] The biased member may interface with a single type of clamp, for example a G-clamp or a variety of types of clamp.

[0009] Alternatively the biased member may be a separate component to the body. Preferably the biased member is a separate component to the body thereby allowing removal and replacement of the biased member without replacement of the entire device. Further, when the biased member is a separate component, this may allow replacement of the biased member for another biased member having a different spring force.

[0010] The biased member may be located on the first side of the body or the second side of the body. Alternatively, the biased member may be located between the first and second sides of the body. Preferably the biased member is located between the first and second sides of the body.

[0011] The body may be made of a single piece of material or a plurality of sub components joined together. The body may be a substantially circular, square, rectangular or higher sided polygon shape or freeform shape and may comprise more than two sides. The first and second sides may be substantially coplanar although in an alternative arrangement, planes defined by the first and second sides of the body may be angularly offset in one or more axes.

[0012] In another arrangement, the second side of the body may comprise a geometry configured to be conformal to a workpiece. For example, the second side of the body may comprise a predefined geometry designed to mate with a predefined workpiece geometry in use. Alternatively, the second side may comprise a malleable surface configured to adapt to a plurality of workpiece geometries. In a preferable arrangement, the body comprises a substantially rectangular shape. The body may

further comprise an ergonomic shape or handle to enable handling by an operator in a manufacturing operation.

[0013] According to one example, the body may further comprise a cavity, the cavity configured to retain the biased member; the body comprising an opening from the first side to the cavity, wherein the device is configured to receive the foot of the clamp through the opening. The cavity may prevent the biased member from fouling caused by adhesive or containments such as dirt and debris. Furthermore, the opening may facilitate positive location of the foot against the biased member and prevent slippage of the clamp in use.

[0014] According to one example, the body further comprises a lateral opening between the first and second sides of the body wherein the lateral opening is configured to allow the biased member to be removed from the cavity. In other words, there is provided a lateral opening in a side of the body between the first and second sides. The lateral opening into the cavity allows the biased member to be removed laterally with respect to the first and second sides of the body. This may allow for maintenance, repair or replacement of the biased member without replacement of the entire body of the device. In some arrangements, the lateral opening may comprise a covering such as a removable panel or door to protect the cavity from fouling caused by adhesive or contaminants such as dirt and debris.

[0015] In some examples, the opening and the lateral opening may be combined as a single opening. In other words, the opening from the first side to the cavity extends between the first and second sides of the body to encompass the lateral opening such that the single opening between the first side to the cavity appears open-ended when viewed from the side of the body. This arrangement may allow more efficient fabrication of the device, in particular when the device is manufactured from a solid billet, both the opening, cavity and lateral opening may be manufactured using an undercut drill bit. This arrangement may also be advantageous when the device is manufactured using additive techniques by eliminating overhangs in the structure. In an alternative arrangement, the opening from the first side to the cavity is formed as an opening separate from the lateral opening between the first and second sides of the body.

[0016] According to one example, the lateral opening is configured to provide an interference fit against the biased member. The lateral opening may comprise dimensions substantially equal to the outer dimensions of the biased member e.g. the dimensions of the lateral opening may be the widest width and height of the biased member. Alternatively, the lateral opening may comprise dimensions in the range of from 0 to 20% less than the outer dimensions of the biased member. Preferably the lateral opening comprises dimensions 10% less than the outer dimensions of the biased member. The interference fit allows the biased member to be retained within the cavity without accidental displacement from the cavity during use.

[0017] According to one example, the cavity is further configured to retain the foot of the clamp and the lateral opening is configured to allow the foot to be removed from the body. In this way, the foot may be inserted laterally with respect to the first and second sides of the body into the cavity thus once the foot of the clamp is inserted into the cavity, the device as a whole is attached to the clamp. Advantageously, the foot is protected from fouling caused by adhesive or containments such as dirt and debris.

[0018] According to one example the lateral opening is configured to provide an interference fit against the foot of the clamp. The lateral opening may comprise dimensions substantially equal to the outer dimensions of the clamp foot e.g. the dimensions of the lateral opening may be the widest width and height of the clamp foot. Alternatively, the lateral opening may comprise dimensions in the range of from 0 to 20% less than the outer dimensions of the clamp foot. The interference fit allows the clamp foot to be retained within the cavity without accidental displacement from the cavity during use.

[0019] According to one example the body comprises a load cell, the load cell configured to measure a received pressure from the clamp. The load cell may be configured to measure pressure exerted from the clamp onto the body of the device. Preferably the load cell is configured to measure pressure exerted from the clamp onto the biased member. The load cell may be placed in a location substantially coaxial with the biased member in order to accurately obtain measurements of pressure exerted by the clamp. Provision of a load cell within the device allows the torque of the clamp to be accurately set thereby ensuring the correct pressure is applied to the workpiece. In one example the load cell is a half-bridge strain gauge load cell.

[0020] According to one example the load cell is connected to a load indicator configured to provide a visual indication of the received pressure from the clamp. The load indicator may be an LED configured to turn on or change colour when the correct pressure is applied to the load cell. For example, the LED may show a first colour, e.g. red, when an incorrect pressure is applied to the load cell and be configured to change to a second colour, e.g. green, when a correct pressure is applied to the load cell. Furthermore, the load indicator may be a screen, e.g. a liquid crystal display, configured to show a measured pressure in real time to an operator. The load indicator may be configured to indicate when the received pressure from the clamp is within a predetermined acceptable range or tolerance.

[0021] According to one example the load cell further comprises an external connection for exporting information relating to the received pressure from the clamp to an external device, e.g. a computing device. In this way, information may be exported to the external device for analysis or real time fault reporting. The external connection may be a wired connection, e.g. an electric cable. Alternatively the external connection may comprise a

wireless connection, e.g. Bluetooth™. The external connection may alternatively be configured to interface with so called 'smart tools', such as clamps with auto torque calibration, or with further clamping devices as herein described.

[0022] The device may comprise an onboard processor connected to the load cell for determining the exerted pressure on the device from the measurements taken by the load cell. Optionally, the onboard processor is connected to the load indicator to control the load indicator.

[0023] The device may further comprise an input connected to the load cell to allow a predetermined threshold measurement to be set by a user. Optionally, the input is connected to the load indicator and/or onboard processor. Alternatively, a predetermined threshold measurement may be set by the external device and uploaded to the device via the external connection.

[0024] In the case of a plurality of devices being used in a manufacturing operation, the plurality of devices may be able to communicate with each other via the external connection. There may be provided more than one external connection for connection to a plurality of external devices or adjacent clamping devices.

[0025] According to one example the surface comprises a non-slip layer for abutment against the workpiece. In this way, the device may be held in a fixed place against the workpiece when clamped. This may be useful where a workpiece comprises geometries which are not conformal to the surface of the body of the device.

[0026] According to one example, the second side of the body comprises a plurality of feet for abutting the workpiece. In this way, pressure exerted by the clamp may be distributed across a greater area of the workpiece. This may protect the workpiece from damage due to overtightening of the clamp. Furthermore, when a plurality of clamps are used to hold a workpiece, lateral distribution of the force applied by the clamps may allow less clamps to be used and may eliminate localised pressure points across the workpiece which cause changes in the thickness of the adhesive layer. Preferably the second side comprises two feet although in alternative embodiments, the second surface may comprise more than two feet. The placement of the feet may preferably exhibit rotational symmetry about a central axis defined by the biased member. The present inventors have found that distribution of the pressure across a greater area of a workpiece leads to over a 50% reduction in the number of clamps required for a particular manufacturing operation. This allows operators easier access to the workpiece and each individual device and/or clamp during the adhesion process. Further, the probability of localised pressure hotspots which may deform the surface of the workpiece and/or the adhesive layer are reduced.

[0027] According to one example the body is made from a plastic, metal, metal composite or carbon composite material. Preferably the body is made from a plastic, more preferably Nylon 12CF.

[0028] According to a second aspect there is provided

a system for clamping a workpiece comprising a device according to the first aspect and a clamp. In use, the system may further comprise a work piece.

[0029] According to a third aspect, there is provided a method of using a clamping device comprising the steps of:

providing a clamping device according to the first aspect;

providing a clamp;

affixing a foot of the clamp to the biased member of the device;

abutting the surface on the second side of the body of the device against a workpiece; and

applying pressure, via the clamp to the workpiece.

BRIEF DESCRIPTION OF THE FIGURES

[0030] Embodiments of the invention will now be described by way of example only with reference to the figures, in which:

Figure 1 shows an isometric exploded view of an example clamping device;

Figure 2 shows a cross sectional diagram of the clamping device of Figure 1;

Figure 3 shows an isometric view of the clamping device in use with a clamping foot of an adjacent clamp against a workpiece;

Figures 4a & 4b shows a cross sectional diagram of the clamping device of figure 3 in use; and

Figure 5 shows an example method flowchart.

DETAILED DESCRIPTION

[0031] Figure 1 shows an isometric exploded view of a clamping device 100 according to the invention. In this example, the device includes a body 101 made of Nylon 12CF having a first side 102 e.g. top side, and a second opposing side 104 e.g. a bottom side, for contact with a workpiece. The second opposing side 104 is substantially coplanar to the first side 102. The body 101 has a biased member 106, in the form of a disk spring, housed within a cavity 110 located between the first 102 and second 104 sides. The body generally has a rectangular cross sectional shape rounded at each end and has filleted edges to enable ergonomic grip by an operator.

[0032] In this example the body 101 also has an opening 112 from the first side 102 of the body 101 to the cavity 110 and a lateral opening 114 positioned between the first 102 and second 104 side of the body 101 configured to allow the biased member 106 to be removed from the cavity 110. In this example, the opening 112 is also part of the lateral opening 114 such that they form

a single opening. In this example, the lateral opening 114 has cross sectional dimensions 10% smaller than the cross sectional dimensions of the biased member 106 and clamp foot to enable an interference fit between the biased member and clamp foot and the lateral opening.

[0033] In this example, the second side 104 of the body 101 has two separate feet 108a 108b abutting an adjacent workpiece distributed around Axis X. The feet 108a 108b provide a non-slip surface for abutment against an adjacent workpiece.

[0034] In this example, the device 100 includes a half-bridge strain gauge load cell (not shown) and a load indicator 118 which will be described further in reference to Figure 2.

[0035] Figure 2 shows a cross sectional diagram of the device 200. Like the device 100 of Fig 1, the device includes a body 201 with first and second sides 202, 204, feet 208a 208b, biased member 206, the body having an opening 212 from the first side to the cavity 210, a lateral opening 214 and a load indicator 218. The function of each of these parts in the device 200 is similar to that of the corresponding parts in the device 100 of Fig. 1, and for the sake of brevity, a detailed description will not be repeated here.

[0036] As described in relation to Figure 1, the device 200 has a load cell 216 which measures a received pressure when used with a clamp (in other words, the load cell 216 measures the pressure being exerted by the clamp onto the workpiece). In this example, the load cell 216 is substantially coaxial with axis X in line with the central axis defined by the biased member 206. The load cell 216 is connected via a connector 220 e.g. an electric cable, to the load indicator 218. In this example, the load indicator is an LED light. The load indicator 218 may be configured to change between a first colour and second colour e.g. red to green such that the load indicator 218 is configured to change colour once a predetermined threshold measurement has been sensed by the load cell 216. The load cell 216 and load indicator 218 are connected to a power source (not shown) housed within the device 200. In this example, the device 200 has an onboard processor 219 connected to the load cell 216 for determining the exerted pressure on the device 200 from the measurements taken by the load cell 216. In this example, the onboard processor 219 is also connected to the load indicator 218. In this example, the external connection 222 is a wired connection to an external device (not shown).

[0037] Turning to Figure 3, there is shown the device 300 of Figs. 1 & 2 in use. In particular, there is shown the device 300 in use with a clamp 328, the clamp 328 having a foot 326 in abutment with the biased member 306. The biased member 306 functions to locate the foot 326 in the central axis defined by the biased member 306. In this example, the cavity 310 retains the foot 326 in addition to retaining the biased member 306. In this example, the lateral opening 314 is configured to provide an interference fit against both the biased member 306 and foot

326 in order to prevent accidental displacement of the biased member 306 and foot 326 from the cavity 310 in use. In use, the feet (not shown) of the second side of the device 300 are in abutment with a workpiece 324. In this example, the workpiece 324 has two components to be joined together using a layer of adhesive 325. The operation of the device 300 will now be described with reference to Figures 4a & 4b.

[0038] Figures 4a & 4b show the device 400 as substantially described in relation to Figures 1 to 3 in use with a clamp 428. In this example, the clamp is a G-clamp which exerts pressure on a workpiece 424 using a jack screw 429. In a typical manufacturing operation, the workpiece 424 is prepared for bonding by applying a layer of adhesive between components to a predetermined thickness A. The device 400 is attached to the foot (not shown) of the clamp 428 whereupon the clamp 428 is tightened to a predetermined torque so as to exert pressure on the workpiece 424 via the device 400. In this state, the biased member is subject to an axial compression and potential energy is stored in the biased member. During curing of the adhesive, some adhesive may bleed from the workpiece 424 thereby reducing the thickness of the adhesive layer from thickness A to A'. Without the biased member, the device 400 would no longer be in abutment with the workpiece 424 however in use, the biased member expands an axial distance B to maintain a fixed pressure on the workpiece 424. In this example, the biased member releases its stored potential energy and expands an axial distance B equal to the value of the thickness of the adhesive A less the value of A', that is to say, the axial change of thickness of the adhesive layer in the workpiece 424. In alternative arrangements, the biased member may be configured to expand to an axial distance greater than A less the distance of A' - i. e. there is some residual potential energy stored in the biased member even after the adhesive layer has decreased in thickness.

[0039] Figure 5 shows an example method flowchart 500 illustrating a method of using the device according to an embodiment of the invention. The method corresponds to a method of operating any of the devices described above with reference to Figs. 1 to 4. The method comprises the steps of:

- 510 providing a clamp, a workpiece to be clamped and a clamping device as herein described;
- 520 placing the foot of the clamp through the opening of the body and against the biased member of the device;
- 530 abutting the feet on the second side of the body of the device against the workpiece; and
- 540 applying pressure, via the clamp, to the workpiece.

[0040] Whilst certain arrangements of the invention have been described herein with reference to the drawings, it will be understood that many variations and mod-

ifications will be possible without departing from the scope of the invention as defined in the accompanying claims.

Claims

1. A clamping device (100) for use with a clamp, wherein the clamping device comprises:

a body (101) comprising a first side (102) and an opposing second side (104) and a biased member (106), wherein the biased member is configured to receive a foot (326) of the clamp; and
the second side of the body comprising a surface (108b) for applying pressure to a workpiece (324);

wherein, in use, the biased member is configured to maintain a constant pressure on the workpiece.

2. The device according to claim 1 wherein the body further comprises a cavity (110), the cavity configured to retain the biased member; the body comprising an opening (112) from the first side to the cavity, wherein the device is configured to receive the foot of the clamp through the opening.

3. The device according to claim 2 wherein the body further comprises a lateral opening (114) between the first and second side of the body, wherein the lateral opening is configured to allow the biased member to be removed from the cavity.

4. The device according to claim 3 wherein the lateral opening is configured to provide an interference fit against the biased member.

5. The device according to claims 3 or 4 wherein the cavity is further configured to retain the foot of the clamp and the lateral opening is configured to allow the foot to be removed from the body.

6. The device according to claim 5, when dependent on claim 4, wherein the lateral opening is configured to provide an interference fit against the foot of the clamp.

7. The device according to any preceding claim wherein the body comprises a load cell (216), the load cell configured to measure a received pressure from the clamp.

8. The device according to claim 7 wherein the load cell is connected to a load indicator (118) configured to provide a visual indication of the received pressure from the clamp.

9. The device according to claim 7 or 8 wherein the load cell further comprises an external connection (222) for exporting information relating to the received pressure from the clamp to an external device.

10. The device according to any preceding claim wherein the surface comprises a non-slip layer for abutment against the workpiece.

11. The device according to any preceding claim wherein the second side of the body comprises a plurality of feet for abutting the workpiece.

12. The device according to any preceding claim wherein the body is made from a plastic.

13. A system for clamping a workpiece comprising:

a device according to any preceding claim; and
a clamp (428).

14. A method of clamping a workpiece, wherein the method comprises:

providing a clamping device according to any one of claims 1 to 12;
providing a clamp;
affixing a foot of the clamp to the biased member of the device;
abutting the surface on the second side of the body of the device against a workpiece; and
applying pressure, via the clamp to the workpiece.

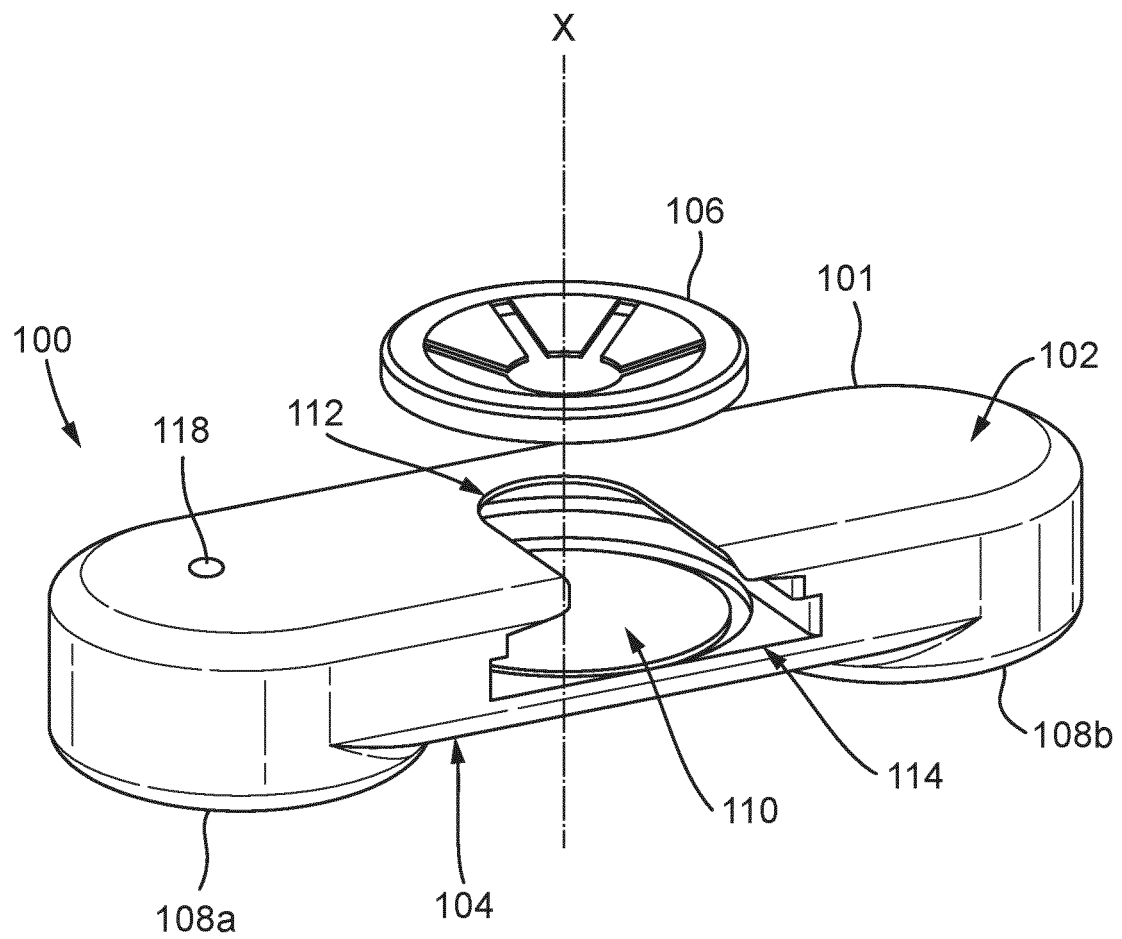


Fig. 1

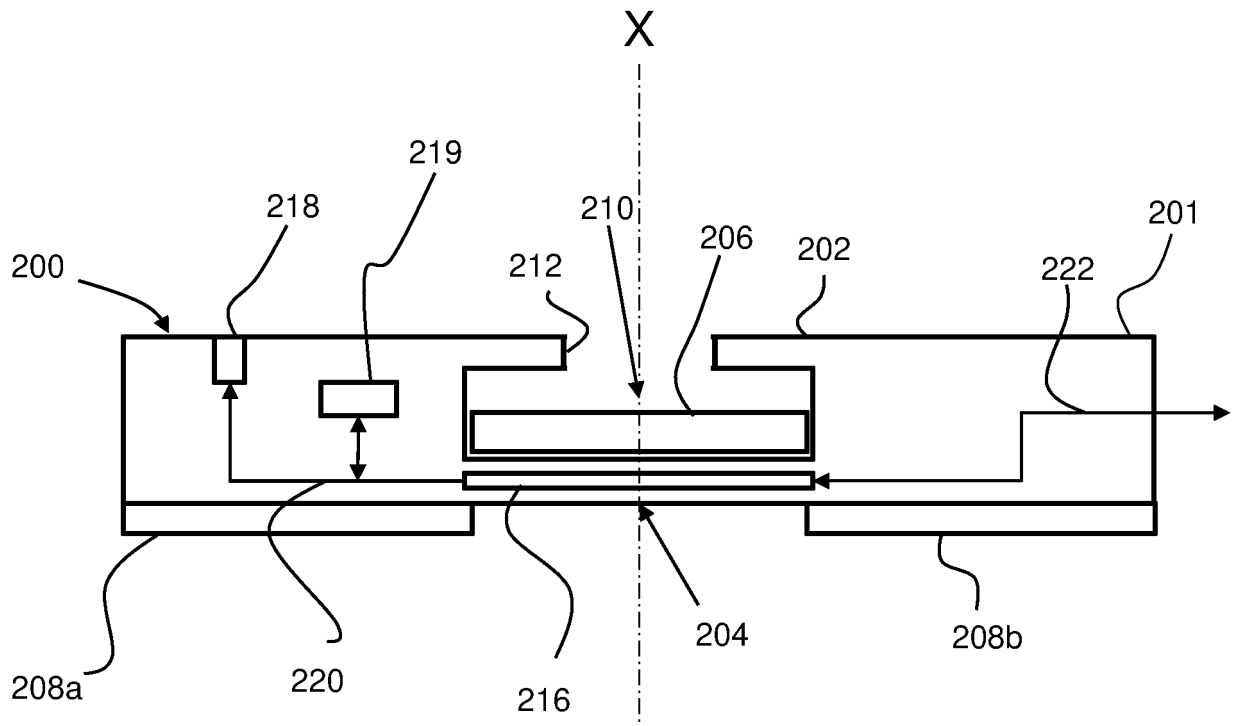


Fig.2

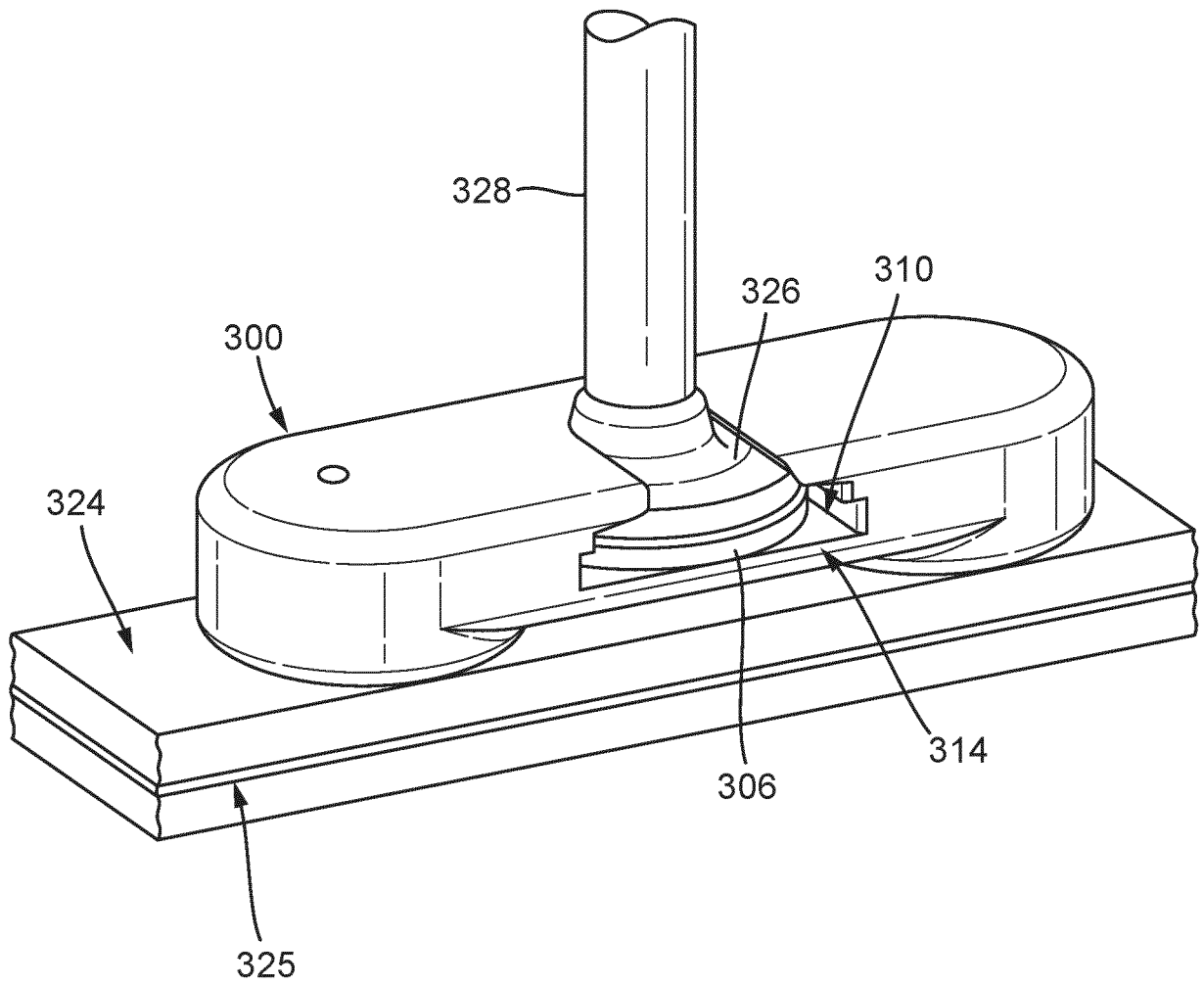


Fig. 3

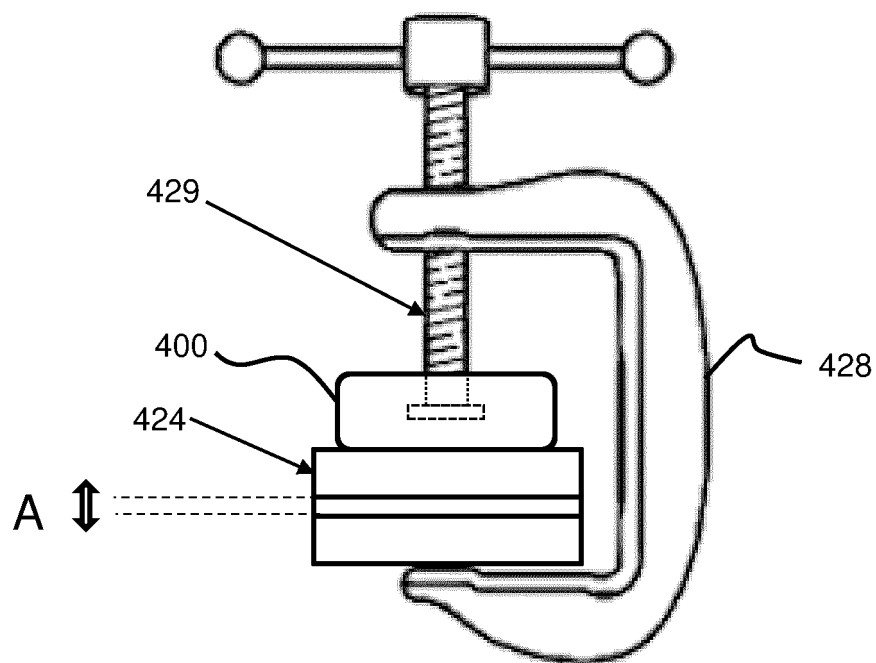


Fig. 4a

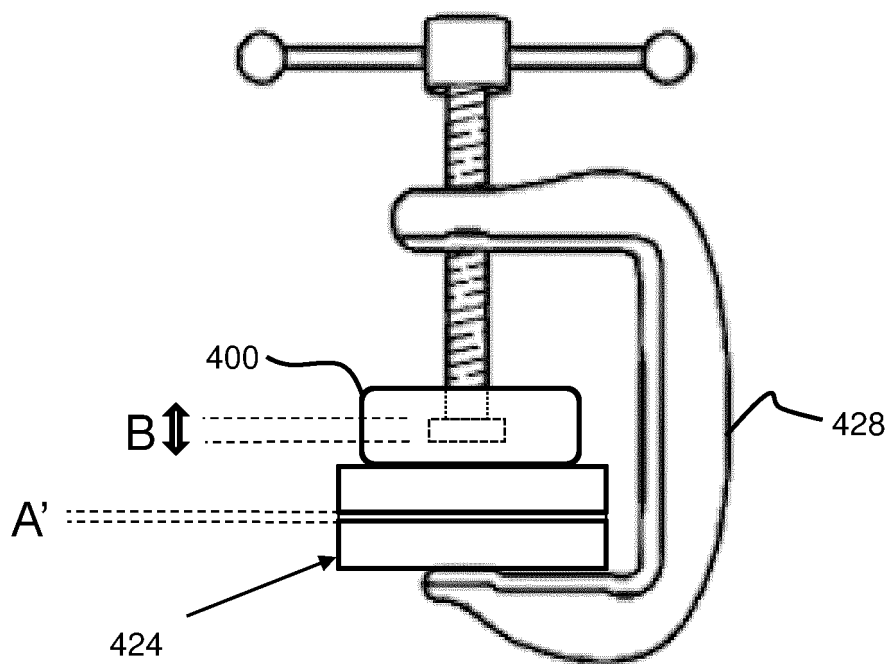


Fig. 4b

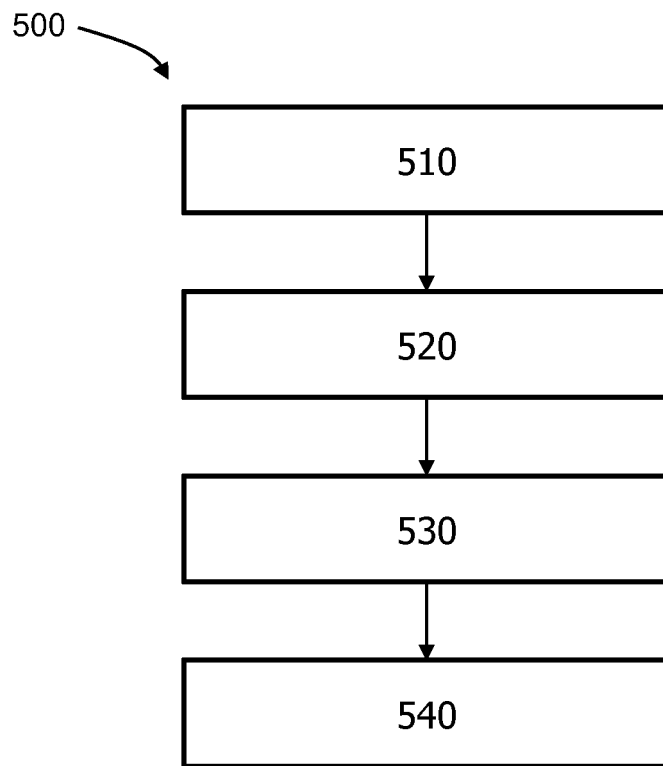


Fig.5



EUROPEAN SEARCH REPORT

Application Number

EP 23 27 5048

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
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A	* paragraph [0030] - paragraph [0045]; figures 1-13 *	2-9	B25B5/10 B25B5/16
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TECHNICAL FIELDS SEARCHED (IPC)

B25B

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
The Hague	27 October 2023	Pothmann, Johannes
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document		

EPO FORM 1503 03.82 (P04C01)

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

EP 23 27 5048

5 This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
The members are as contained in the European Patent Office EDP file on
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27-10-2023

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