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(54) **FASTENING MECHANISM**

BEFESTIGUNGSMECHANISMUS

MÉCANISME DE FIXATION

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(56) References cited:
**WO-A1-97/47436 US-A- 5 407 293
US-A- 5 482 413 US-A1- 2005 034 573**

EP 4 132 750 B1

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Description

[0001] The present invention relates to a fastening mechanism between a male and a female component, particularly, although not exclusively, the handle and head of a torque wrench.

[0002] Torque wrenches are fundamental tools used in many industries, particularly the manufacturing and maintenance industries, to apply a predetermined amount of torque to a fastener (e.g. a nut, screw or bolt).

[0003] A typical torque wrench may comprise an end fitting attached to the end of a handle. The end fitting is shaped to engage with the head of a particular fastener. Once the end fitting has engaged the head of the fastener, the handle may be pivoted around the fastener to exert the required torque.

[0004] It is known in the art to provide end fittings that may be detached from the handle of the torque wrench. This means that different end fittings may be respectively attached to a single handle, thus increasing the versatility of the tool.

[0005] The current method of fastening a detachable end fitting to the handle of a torque wrench involves the use of a plunger-and-hole arrangement. This arrangement comprises a male component and a female component, which may be a spigot on the handle and an opening on the end fitting of the tool respectively (or vice versa). The male and female components respectively further comprise a radial plunger and a corresponding hole. The components are fastened together by the engagement of the spring-biased plunger within the hole when the spigot is inserted into the female component. In order to disengage the components, a protruding push button, formed by the distal end of the plunger, must be pressed to disengage the plunger from the hole, thereby allowing the male component to be withdrawn from the female component.

[0006] This mechanism is almost ubiquitous within the art. However, the Applicant has recognised that this arrangement is unsatisfactory for a number of applications. The push button and corresponding plunger are typically awkward to actuate in normal use of a torque wrench, and in some cases disconnection may be achieved only through the use of a dedicated tool (e.g. to depress the plunger). Furthermore, torque wrenches are often used in environments that may be cold, wet or dirty. Such conditions may present the user with extreme difficulty in actuating the typical fastening mechanism, thereby inhibiting the performance of a task.

[0007] Additionally, the Applicant has identified that the conventional fastening mechanism is incompatible with tools that must be used in proximity to live electrical components. It is a requirement of the relevant standards that such tools are covered in an insulating material to protect the user. Therefore, the current fastening mechanism used in the art (i.e. the plunger-and-hole mechanism) is inadequate for such applications, as the insulating layer would have to be removed in order to

depress the plunger, thereby substantially increasing the level of inconvenience and risk to the user.

[0008] The present invention seeks to provide a fastening mechanism that overcomes these shortcomings.

[0009] US 5 482 413 A discloses a pneumatic tool comprising a motor element that includes a body in which a pneumatic motor is housed. WO 97/47436 A1 discloses a clamping chuck that holds an auxiliary rotary tool such as a screwdriver or a cutting tool. US 5 407 293 A discloses a coupling apparatus for a medical instrument. US 2005/034573 A1 discloses a hand tool that includes a retractable shank, a handle, an elastic member, and at least one fixing pin.

[0010] When viewed from a first aspect, the invention provides a fastening mechanism comprising a male component and a female component;

the female component comprising

a bore arranged to receive the male component;
and
a locking member protruding across the bore;

the male component defining

a groove, extending at least partially around an outer surface of the male component and arranged, at a first position of the female component relative to the male component, to receive the locking member; and
a cutaway, extending from the groove and arranged, at a second position of the female component relative to the male component, to receive the locking member.

[0011] Thus it will be seen that the present invention provides a fastening mechanism comprising a male component and a female component. The male component is arranged to be inserted into a bore of the female component, thereby locating a locking member of the female component within a groove of the male component. This engagement prevents relative axial displacement of the male and female components. The locking member of the female component is further arranged to be received within a cutaway of the male component. The engagement between the locking member and the cutaway helps to prevent both the relative axial and rotational movement of the male and female components, thereby providing a more reliable connection, e.g. which may not be disconnected accidentally.

[0012] It will be appreciated that the present invention may provide a fastening mechanism that can be fastened and unfastened easily by a user, without requiring the use of parts (such as a plunger) that are awkward to move. Instead, the interlocking of the components is provided by the geometries of the components alone.

[0013] Furthermore, as the claimed fastening mechanism may be realised without the use of protruding parts,

the present invention may be provided with a layer of insulating material without impairing its function. Therefore, the claimed fastening mechanism is suitable for use with insulated tools and indeed in a set of embodiments the male and female components both comprise an electrically insulating external layer - e.g. one at least .

[0014] In some embodiments, the male component comprises a handle of a tool (e.g. a torque wrench). However, in some embodiments, the male component comprises an end fitting (e.g. for attaching to a handle of a tool). In some embodiments, the female component comprises a handle of a tool (e.g. a torque wrench). However, in some embodiments, the female component comprises an end fitting (e.g. for attaching to a handle of a tool).

[0015] The end fitting may comprise an engagement feature for engaging, in use, with a fastener. In some embodiments, the end fitting may comprise an extension for a handle of a tool.

[0016] The male component may comprise a spigot. The spigot may be arranged at a distal end of the male component. In some embodiments, the spigot is substantially cylindrical. The spigot may be between 5mm and 35mm in diameter.

[0017] In some embodiments, the bore is cylindrical. The bore may extend along a central axis of the female component. The bore may be arranged to receive the spigot of the male component.

[0018] The locking member may comprise a pin, e.g. a cylindrical pin.

[0019] In some embodiments, the groove comprises an arcuate (e.g. semi-circular) cross-section. The groove may extend all the way around the outer surface of the male component or around only a portion thereof. It will be appreciated that the groove may provide a channel for the locking member that restricts relative axial movement of the locking member, but allows relative rotational movement. This may help to improve the ease with which the locking component is subsequently brought into alignment with the cutaway in order to move the female component from the first position to the second position.

[0020] In some embodiments, the male component is shaped to cooperate with the female component such that the male component can only be inserted into the female component in a limited number of axial orientations, e.g. only one. In a set of such embodiments this is achieved through the locking member cooperating with the shape of the male component. In a set of embodiments the male component comprises a key surface dimensioned to slide past a part of the female component - such as the locking member - when the male component is inserted into the bore. The key surface may extend axially between a distal end of the male component and the groove. In a set of embodiments the key surface is flat.

[0021] In some embodiments, the male component comprises a stop. The stop may comprise a surface in a plane perpendicular to the longitudinal axis of the male component. The stop may extend perpendicularly from

the key surface. In some embodiments, in the first position of the female component relative to the male component, the locking member is arranged to abut the stop. The groove may be adjacent the stop. Thus, the stop may help to ensure that, in the first position of the female component relative to the male component, the locking member is brought to rest at the axial location of the groove. This helps to improve the ease with which the locking member may be brought into engagement with the groove.

[0022] In some embodiments, the cutaway extends from a wall of the groove. In some embodiments, the cutaway extends from a distal wall of the groove towards the distal end of the male component.

[0023] In embodiments wherein the male component comprises a key surface, the cutaway may be perpendicular to the key surface. However, it will be appreciated that the cutaway and the key surface may be separated by any suitable or desired angle. In some embodiments, the cutaway extends from a radial edge of the key surface.

[0024] In some embodiments, the cutaway extends to at least the same radial depth as the depth of the groove. This may help to ensure that, when the female component is moved from the first position to the second position, the locking member is moved from the groove into the cutaway.

[0025] The cutaway may be defined by a planar first surface having a normal parallel to the longitudinal axis of the male component and a second surface radially and axially perpendicular to the first surface. When the locking member is brought into engagement with the cutaway, the first surface may act to limit relative axial displacement of the male and female components and the second surface may act to limit relative rotational movement. This arrangement may reduce the likelihood that the locking member accidentally slips out of engagement with the cutaway.

[0026] In some embodiments the cutaway defines a seat for the locking member. The seat may be shaped to match the profile of the locking member. The seat may define a curved (e.g. arcuate) seat for the locking member. This may be particularly advantageous in embodiments wherein the locking member is cylindrical. Providing a seat for the locking member that matches the profile of the locking member may help to lock the locking member more securely into position within the cutaway, thereby reducing the risk of accidental disengagement.

[0027] In some embodiments, the fastening mechanism comprises a biasing member. The biasing member may be arranged on the female component. In some embodiments the biasing member is arranged to bias the male component away from the female component when the male component is inserted into the bore. In a set of embodiments the biasing member is arranged to bias the locking member into the cutaway. This can remove the requirement for the locking member and the cutaway to be manually moved into engagement,

thus improving the ease with which the fastening mechanism may be operated. Furthermore, the bias of the biasing member may improve the engagement between the locking member and the cutaway such that the risk of accidental disengagement is reduced.

[0028] The biasing member could be arranged within the bore e.g. to engage a distal end of the male component when the male component is received within the bore. However, in some embodiments, the biasing member is arranged on the male component. The biasing member may be arranged on a distal end of the male component. The biasing member may be arranged to engage an end surface of the bore when the male component is received within the bore.

[0029] The biasing member could comprise a magnet. However, in some embodiments the biasing member comprises a spring.

[0030] Advantageously, the male and female components are fastened by moving the female component relative to the male component from the first position to the second position, e.g. rotationally. In some embodiments, the components are arranged to be rotated by ninety degrees relative to each other. The components may also be moved into the second position axially e.g. by the biasing member.

[0031] It will be appreciated that, where the male component comprises a key surface, the components may be arranged such that they can be mutually rotated once the male component has been inserted sufficiently to move the key surface past the cooperating part of the female component.

[0032] Typically, the male and female components are arranged to be unfastened by moving the female component relative to the male component from the second position to the first position. In some embodiments, e.g. where a biasing member is provided, the locking member must first be axially moved out of the cutaway. The components may be subsequently rotated relative to each other to allow axial separation.

[0033] An embodiment of the invention will now be described, by way of example only, with reference to the accompanying drawings in which:

Figure 1 shows a perspective view of a male component of a fastening mechanism in accordance with an embodiment of the invention;

Figure 2 shows a side view of the male component of Figure 1 and a cross section of a corresponding female component, wherein the components are not fastened together;

Figure 3a shows a partly transparent side view of the male and female components of Figure 2, wherein the male component has been inserted into the female component;

Figure 3b shows a partly transparent perspective view of the male and female components of Figure 3a;

Figure 4 shows a plan view of the male and female

components of Figure 2 at an intermediate stage, wherein the female component has been rotated relative to the male component

Figure 5a shows a plan view of the male and female components of Figure 2 wherein the male component and the female component have been fastened together; and

Figure 5b shows a perspective view of the male and female components of Figure 5a.

[0034] Figure 1 shows a perspective view of a male component 4 of a fastening mechanism 2 in accordance with an embodiment of the present invention.

[0035] In this embodiment, the fastening mechanism 2 is used to connect a removable end fitting 6 (see Figure 2) to the spigot 4 of a torque wrench handle 3. The end fitting 6 may correspond to a particular shape of the head of a fastener, such as a nut or bolt or have a further spigot to allow a suitable socket to be fitted to it, as is well known in the art.

[0036] The spigot 4 comprises a cylindrical body portion 8 which extends axially from the centre of the handle 3. The spigot 4 further defines a circumferentially extending groove 12. A flat key surface 10 is provided at the distal end of the spigot 4. The plane of the flat surface 10 is parallel to the central axis 5 of the handle 3 and spigot 4. The flat surface 10 extends between the distal end of the spigot 4 and the circumferential groove 12.

[0037] The spigot 4 further defines a cutaway 14 that extends from a radial edge of the flat surface 10 in a direction that is perpendicular to the plane of the flat surface 10.

[0038] The spigot 4 further comprises a biasing member 16, e.g. a compression spring. In the uncompressed state of the biasing member 16, an end of the biasing member 16 protrudes axially from the distal end of the spigot 4. In a compressed state of the biasing member 16, the end of the biasing member 16 is flush with the distal end of the spigot 4.

[0039] Figure 2 shows a side view of the spigot 4 shown in Figure 1 and the removable end fitting 6 prior to attachment.

[0040] The end fitting 6 comprises a body 18 that could comprise any desired functional head for engaging with a workpiece. (not shown). The body 18 of the end fitting 6 further defines a cylindrical bore 20 that extends partially into the body 18. The diameter of the bore 20 is designed to accommodate the spigot 4.

[0041] The end fitting 6 further comprises a locking member in the form of a cylindrical pin 24 that protrudes across the bore 20 from one side of the bore 20 to the other (i.e. along the path of a chord). The diameter of the pin 24 is substantially equal to the width of the groove 12 in the surface of the spigot 4.

[0042] Operation of the fastening mechanism 2 will now be described.

[0043] In order to engage the fastening mechanism 2, the handle 3 is first rotated about its longitudinal axis such

that the flat surface 10 of the spigot 4 is parallel to the axis of the cylindrical pin 24 in the end fitting 6 - as shown in Figure 2. The spigot 4 is then inserted into the bore 20 such that the pin 24 slides along the flat surface 10.

[0044] The spigot 4 is pushed axially into the bore 20 until the pin 24 of the end fitting 6 abuts the end surface 8a of the cylindrical portion 8 of the spigot 4. This arrangement is shown in Figures 3a and 3b. To reach this position, the force of the biasing member 16 that opposes the insertion of the spigot 4 into the bore 20 as it bears against the end of the bore 20 must be overcome such that the end of the biasing member 16 is pressed flush into the distal end of the spigot 4, i.e. the biasing member 16 is in the compressed state.

[0045] Figure 4 shows a plan view of the fastening mechanism 2 after a subsequent stage of fastening. During this stage, while the biasing member 16 is in the compressed state and the spigot 4 has been inserted sufficiently to move the flat surface 10 past the pin 24, the end fitting 6 is rotated 90 degrees relative to the handle 3 such that the pin 24 is brought into engagement with the groove 12 and then rotates around it. This attaches the end fitting 6 to the spigot 4 of the handle 3 by preventing them from being axially separated.

[0046] Once the force pushing the spigot 4 into the bore 20 is removed, the bias force of the biasing member 16 pushes the end fitting 6 away from the spigot 4, thereby moving the pin 24 into engagement with the cutaway 14, as shown in Figures 5a and 5b. This engagement between the pin 24 and the cutaway 14 ensures that the pin 24 is locked into position and prevents both relative axial and rotational movement between the spigot 4 and the end fitting 6. The biasing member 16 ensures the seating of the pin 24 within the cutaway 14 to prevent accidental disengagement.

[0047] The fastening mechanism 2 may be released by first exerting an axial force on the spigot 4, against the force of the biasing member 16, such that the pin 24 is brought out of engagement with the cutaway 14. In this way, the fastening mechanism 2 is moved to the intermediate stage shown in Figure 4.

[0048] The end fitting 6 can then be rotated 90 degrees relative to the spigot 4, thereby sliding the pin 24 circumferentially around the groove 12 until the pin 24 is brought into alignment with the flat surface 10, as shown in Figures 3a and 3b. At this point, the spigot 4 may be withdrawn from the bore 20 of the end fitting 6 to fully release the fastening mechanism 2.

[0049] Thus it will be seen by those skilled in the art that the embodiment described above provides a simple yet secure fixing mechanism which does not rely on fiddly alignment of sprung pins and apertures but rather can be easily attached and detached by simply pressing and twisting.

Claims

1. A fastening mechanism (2) comprising a male component (4) and a female component (6);

the female component comprising

a bore (20) arranged to receive the male component; and
a locking member (24) protruding across the bore;

the male component defining

a groove (12), extending at least partially around an outer surface of the male component and arranged, at a first position of the female component relative to the male component, to receive the locking member; and
a cutaway (14), extending from the groove and arranged, at a second position of the female component relative to the male component, to receive the locking member.

2. The fastening mechanism (2) as claimed in claim 1, wherein the male component (4) comprises a handle of a tool and the female component (6) comprises an end fitting.
3. The fastening mechanism (2) as claimed in any preceding claim, wherein the locking member (24) is cylindrical.
4. The fastening mechanism (2) as claimed in any preceding claim, wherein the groove (12) comprises an arcuate cross-section.
5. The fastening mechanism (2) as claimed in any preceding claim, wherein the male component (4) comprises a key surface (10) dimensioned to slide past the locking member (24) when the male component is inserted into the bore (20).
6. The fastening mechanism (2) as claimed in claim 5, wherein the key surface (10) extends axially between a distal end of the male component (4) and the groove (12).
7. The fastening mechanism (2) as claimed in claim 5 or 6, wherein the key surface (10) is flat.
8. The fastening mechanism (2) as claimed in any of claims 5 to 7, wherein the cutaway (14) is perpendicular to the key surface (10).
9. The fastening mechanism (2) as claimed in any preceding claim, wherein the male component (4)

comprises a stop (8a) and wherein, in the first position of the female component (6) relative to the male component, the locking member (24) is arranged to abut the stop.

10. The fastening mechanism (2) as claimed in claim 9, wherein the groove (12) is adjacent the stop (8a).
11. The fastening mechanism (2) as claimed in any preceding claim, wherein the cutaway (14) extends from a wall of the groove (12).
12. The fastening mechanism (2) as claimed in any preceding claim, wherein the cutaway (14) extends to at least the same radial depth as the depth of the groove (12).
13. The fastening mechanism (2) as claimed in any preceding claim, wherein the cutaway (14) comprises a planar first surface having a normal parallel to the longitudinal axis of the male component (4) and a second surface radially and axially perpendicular to the first surface.
14. The fastening mechanism (2) as claimed in any preceding claim, wherein the cutaway (14) defines a curved seat for the locking member (24).
15. The fastening mechanism (2) as claimed in any preceding claim, further comprising a biasing member (16) arranged to bias the locking member (24) into the cutaway (14) at the second position.

Patentansprüche

1. Befestigungsmechanismus (2), der eine männliche Komponente (4) und eine weibliche Komponente (6) umfasst;

wobei die weibliche Komponente umfasst

eine Bohrung (20), die angeordnet ist, um die männliche Komponente aufzunehmen; und

ein Verriegelungselement (24), das durch die Bohrung vorspringt;

wobei die männliche Komponente definiert

eine Nut (12), die sich mindestens teilweise um eine Außenoberfläche der männlichen Komponente herum erstreckt und angeordnet ist, um in einer ersten Position der weiblichen Komponente in Bezug zur männlichen Komponente das Verriegelungselement aufzunehmen; und

einen Ausschnitt (14), der sich aus der Nut

erstreckt und angeordnet ist, um in einer zweiten Position der weiblichen Komponente in Bezug zur männlichen Komponente das Verriegelungselement aufzunehmen.

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2. Befestigungsmechanismus (2) nach Anspruch 1, wobei die männliche Komponente (4) einen Griff eines Werkzeugs umfasst und die weibliche Komponente (6) ein Endstück umfasst.
3. Befestigungsmechanismus (2) nach einem vorstehenden Anspruch, wobei das Verriegelungselement (24) zylindrisch ist.
4. Befestigungsmechanismus (2) nach einem vorstehenden Anspruch, wobei die Nut (12) einen bogenförmigen Querschnitt umfasst.
5. Befestigungsmechanismus (2) nach einem vorstehenden Anspruch, wobei die männliche Komponente (4) eine Schlüsseloberfläche (10) umfasst, die bemessen ist, um am Verriegelungselement (24) vorbeizugleiten, wenn die männliche Komponente in die Bohrung (20) eingesetzt wird.
6. Befestigungsmechanismus (2) nach Anspruch 5, wobei sich die Schlüsseloberfläche (10) axial zwischen einem distalen Ende der männlichen Komponente (4) und der Nut (12) erstreckt.
7. Befestigungsmechanismus (2) nach Anspruch 5 oder 6, wobei die Schlüsseloberfläche (10) flach ist.
8. Befestigungsmechanismus (2) nach einem der Ansprüche 5 bis 7, wobei der Ausschnitt (14) senkrecht zur Schlüsseloberfläche (10) verläuft.
9. Befestigungsmechanismus (2) nach einem vorstehenden Anspruch, wobei die männliche Komponente (4) einen Anschlag (8a) umfasst, und wobei das Verriegelungselement (24) angeordnet ist, um in der ersten Position der weiblichen Komponente (6) in Bezug zur männlichen Komponente am Anschlag anzuliegen.
10. Befestigungsmechanismus (2) nach Anspruch 9, wobei die Nut (12) an den Anschlag (8a) angrenzt.
11. Befestigungsmechanismus (2) nach einem vorstehenden Anspruch, wobei sich der Ausschnitt (14) aus einer Wand der Nut (12) erstreckt.
12. Befestigungsmechanismus (2) nach einem vorstehenden Anspruch, wobei sich der Ausschnitt (14) bis zu mindestens der gleichen radialen Tiefe wie die Tiefe der Nut (12) erstreckt.

13. Befestigungsmechanismus (2) nach einem vorstehenden Anspruch, wobei der Ausschnitt (14) eine flache erste Oberfläche, die eine Normale parallel zur Längsachse der männlichen Komponente (4) aufweist, und eine zweite Oberfläche radial und axial senkrecht zur ersten Fläche umfasst. 5
14. Befestigungsmechanismus (2) nach einem vorstehenden Anspruch, wobei der Ausschnitt (14) einen gekrümmten Sitz für das Verriegelungselement (24) definiert. 10
15. Befestigungsmechanismus (2) nach einem vorstehenden Anspruch, der weiter ein Vorspannelement (16) umfasst, das angeordnet ist, um das Verriegelungselement (24) in der zweiten Position in den Ausschnitt (14) vorzuspannen. 15

Revendications

1. Mécanisme de fixation (2) comprenant un composant mâle (4) et un composant femelle (6) ;
le composant femelle comprenant 25
un alésage (20) agencé pour recevoir le composant mâle ; et
un élément de verrouillage (24) faisant saillie en travers de l'alésage ; 30
le composant mâle définissant
une rainure (12), s'étendant au moins partiellement autour d'une surface extérieure du composant mâle et agencée, en une première position du composant femelle par rapport au composant mâle, pour recevoir l'élément de verrouillage ; et 35
une découpe (14), s'étendant à partir de la rainure et agencée, en une seconde position du composant femelle par rapport au composant mâle, pour recevoir l'élément de verrouillage. 40
2. Mécanisme de fixation (2) selon la revendication 1, dans lequel le composant mâle (4) comprend un manche d'un outil et le composant femelle (6) comprend un embout. 50
3. Mécanisme de fixation (2) selon une quelconque revendication précédente, dans lequel l'élément de verrouillage (24) est cylindrique.
4. Mécanisme de fixation (2) selon une quelconque revendication précédente, dans lequel la rainure (12) comprend une section transversale arquée. 55

5. Mécanisme de fixation (2) selon une quelconque revendication précédente, dans lequel le composant mâle (4) comprend une surface de clé (10) dimensionnée pour glisser au-delà de l'élément de verrouillage (24) lorsque le composant mâle est inséré dans l'alésage (20).
6. Mécanisme de fixation (2) selon la revendication 5, dans lequel la surface de clé (10) s'étend axialement entre une extrémité distale du composant mâle (4) et la rainure (12).
7. Mécanisme de fixation (2) selon la revendication 5 ou 6, dans lequel la surface de clé (10) est plate.
8. Mécanisme de fixation (2) selon l'une quelconque des revendications 5 à 7, dans lequel la découpe (14) est perpendiculaire à la surface de clé (10).
9. Mécanisme de fixation (2) selon une quelconque revendication précédente, dans lequel le composant mâle (4) comprend une butée (8a) et dans lequel, dans la première position du composant femelle (6) par rapport au composant mâle, l'élément de verrouillage (24) est agencé pour venir en butée contre la butée. 25
10. Mécanisme de fixation (2) selon la revendication 9, dans lequel la rainure (12) est adjacente à la butée (8a). 30
11. Mécanisme de fixation (2) selon une quelconque revendication précédente, dans lequel la découpe (14) s'étend à partir d'une paroi de la rainure (12). 35
12. Mécanisme de fixation (2) selon une quelconque revendication précédente, dans lequel la découpe (14) s'étend au moins jusqu'à la même profondeur radiale que la profondeur de la rainure (12). 40
13. Mécanisme de fixation (2) selon une quelconque revendication précédente, dans lequel la découpe (14) comprend une première surface plane présentant une normale parallèle à l'axe longitudinal du composant mâle (4) et une seconde surface radialement et axialement perpendiculaire à la première surface. 45
14. Mécanisme de fixation (2) selon une quelconque revendication précédente, dans lequel la découpe (14) définit un siège incurvé pour l'élément de verrouillage (24). 50
15. Mécanisme de fixation (2) selon une quelconque revendication précédente, comprenant en outre un élément de sollicitation (16) agencé pour solliciter l'élément de verrouillage (24) dans la découpe (14) au niveau de la seconde position. 55

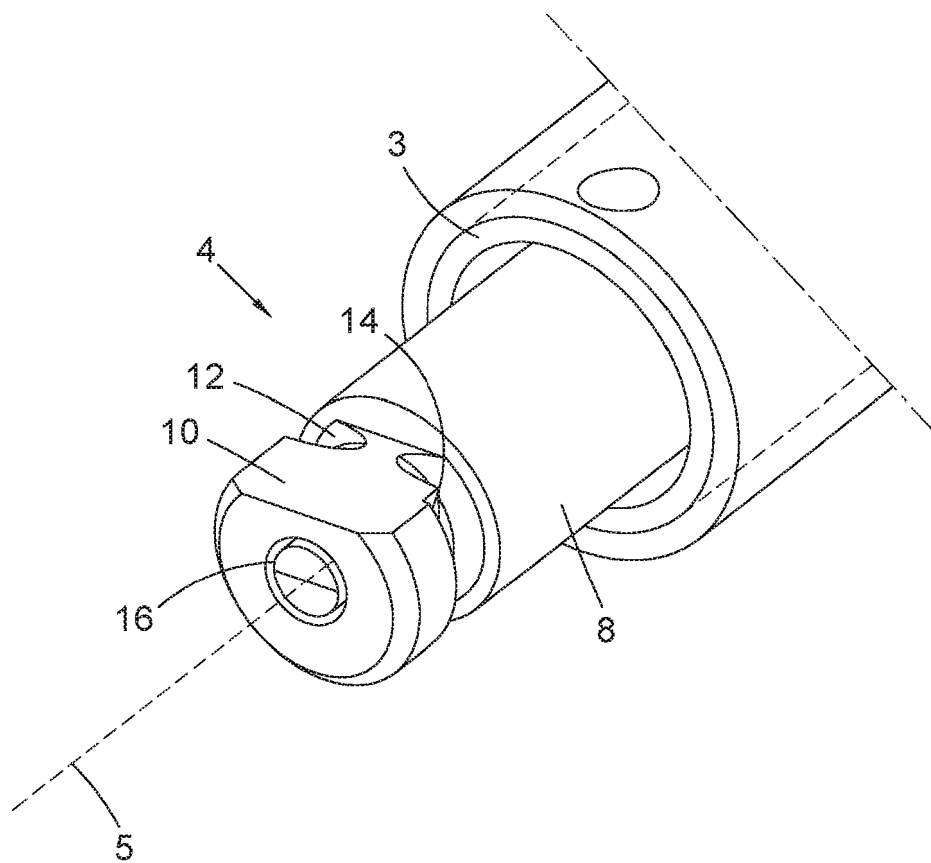


FIG. 1

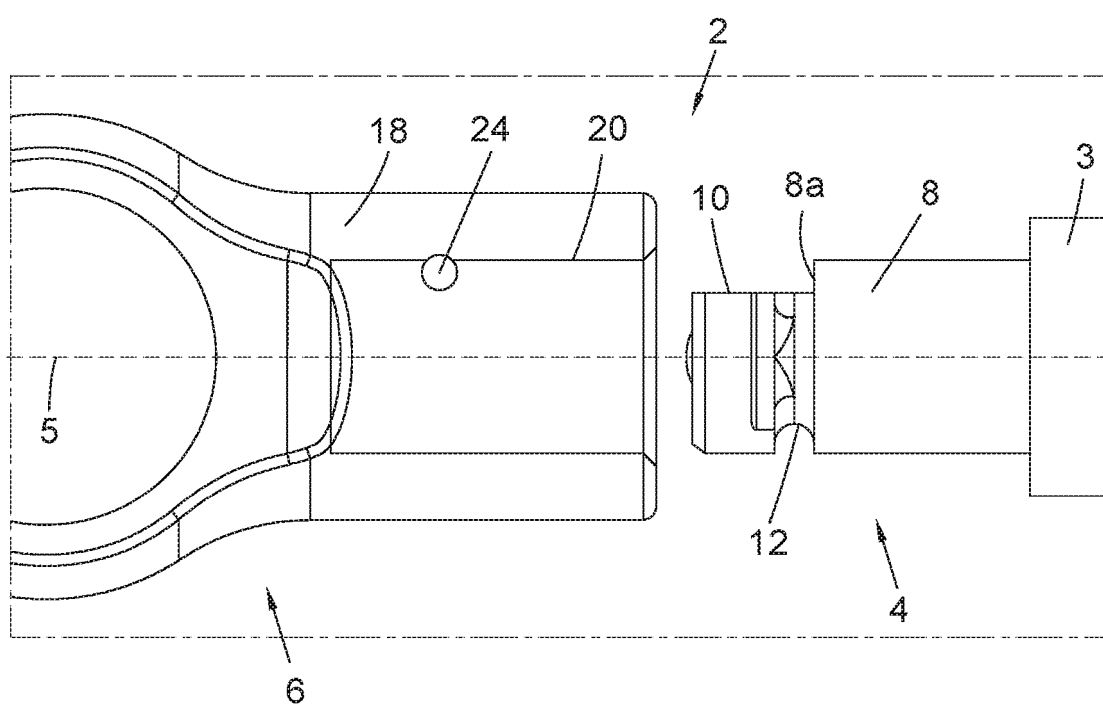


FIG. 2

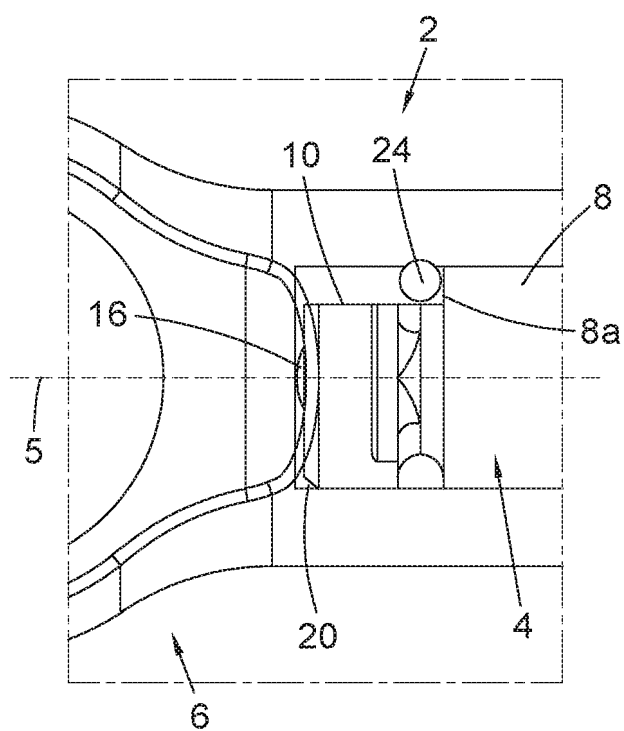


FIG. 3a

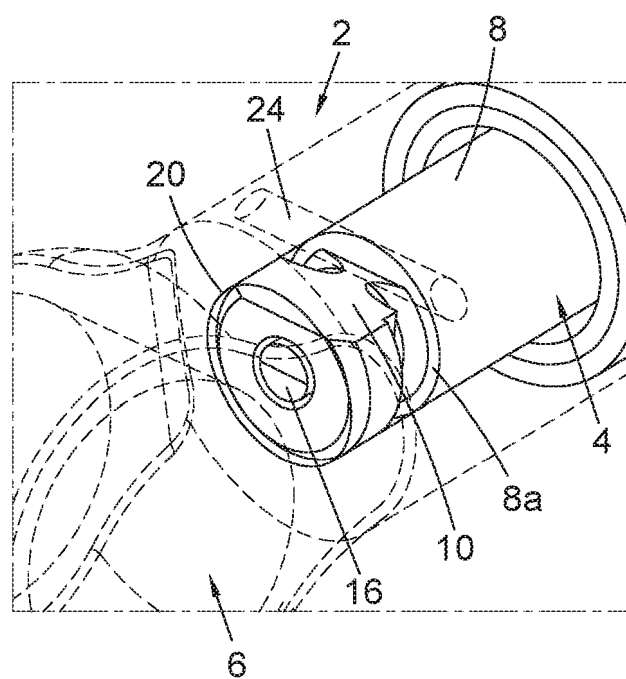


FIG. 3b

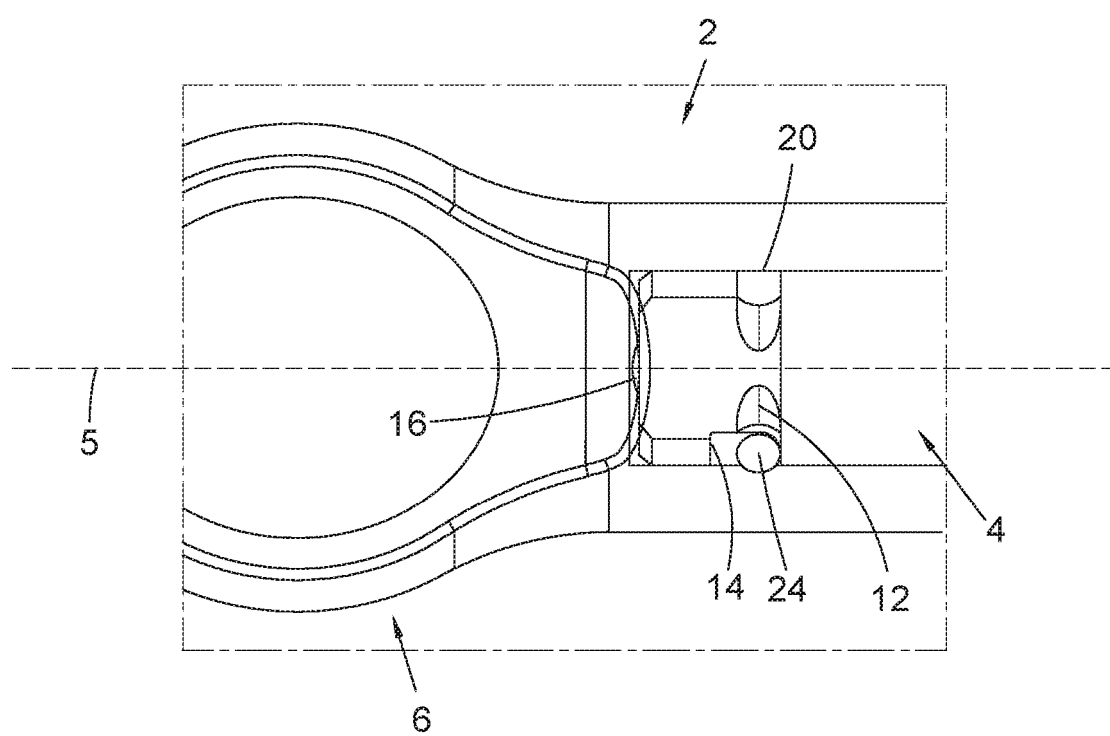


FIG. 4

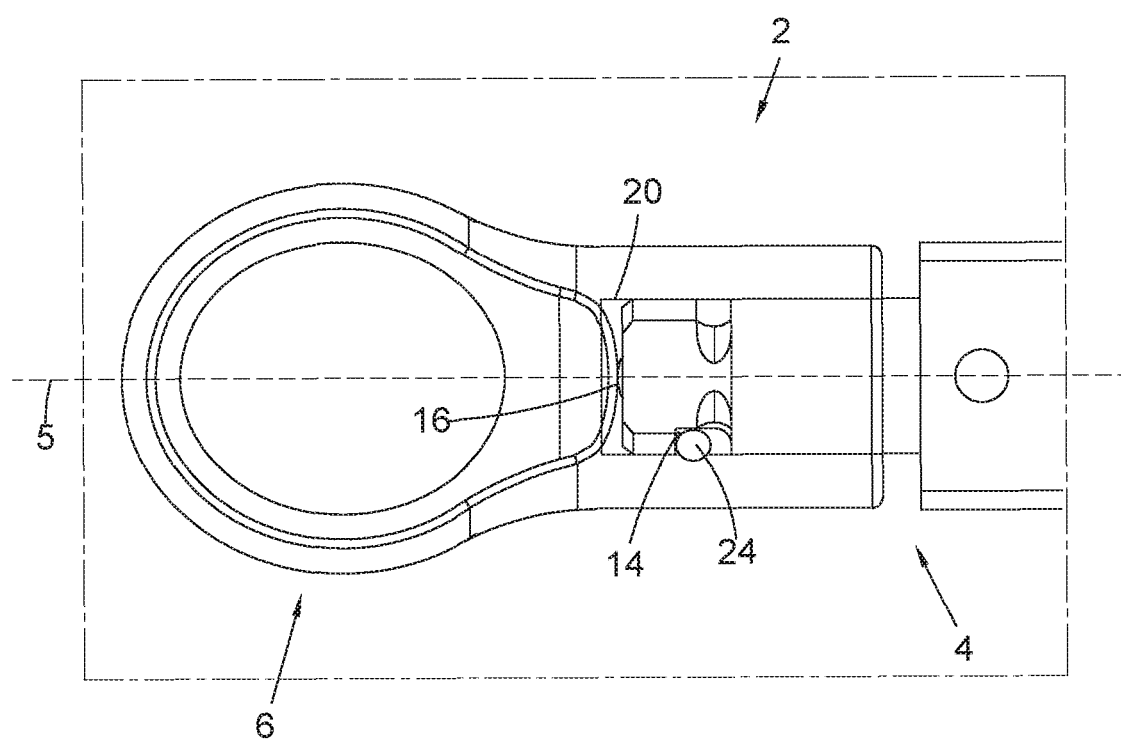


FIG. 5a

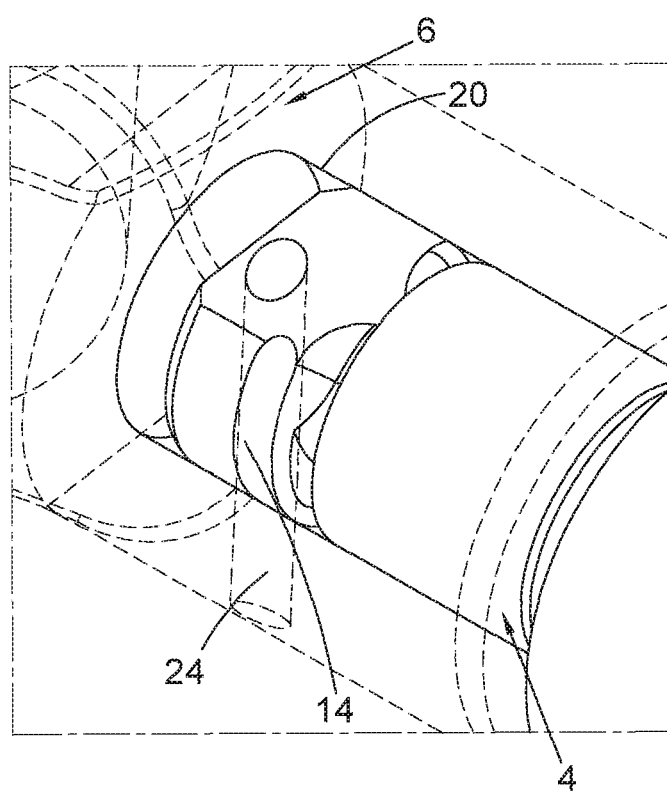


FIG. 5b

REFERENCES CITED IN THE DESCRIPTION

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