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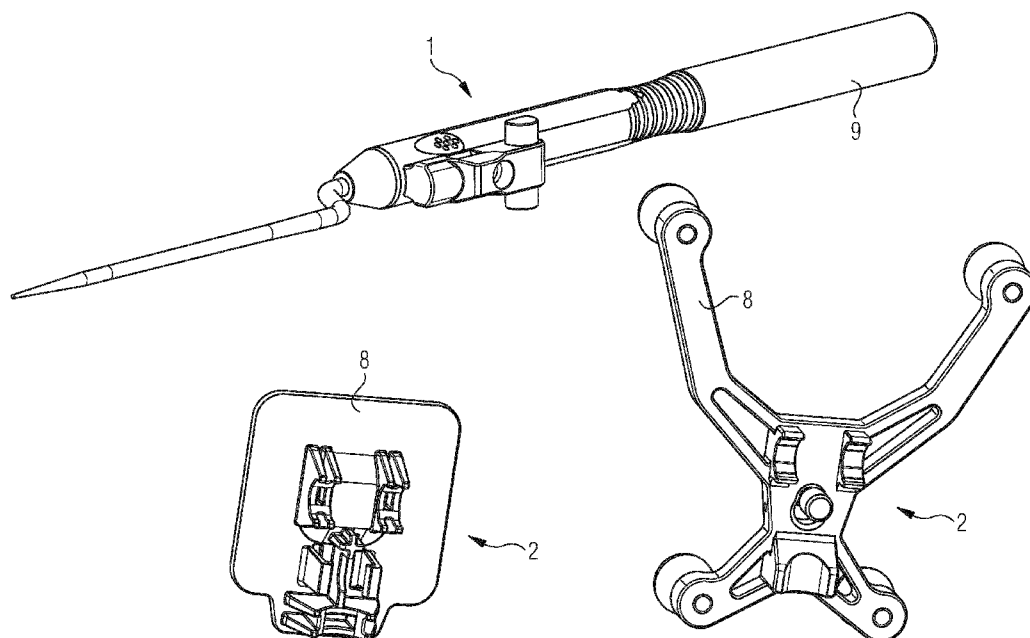


FIG. 1

(57) Abstract: The present invention relates to a tracking marker interface comprising a first interface component (1) and a second interface component (2) adapted to releasably and rigidly engage each other in a statically determined manner and via corresponding first positioning sections (3A, 3B), corresponding second positioning sections (4A, 4B) and corresponding fixation sections (5A, 5B) respectively assigned to the first interface component (1) and to the second interface component (2). The present invention further relates to a system comprising a plurality of such first and second interface components (1, 2) which are adapted to connect to each other.



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## UNIVERSAL TRACKING MARKER INTERFACE

### FIELD OF THE INVENTION

The present invention relates to a tracking marker interface which enables mounting  
10 tracking markers to medical instruments and devices in a statically determined  
manner for tracking and navigation purposes. In particular, the tracking marker  
interface enables mounting various types of tracking markers to instruments and  
devices so as to cover a variety of medical and surgical use cases and to enable the  
use of various tracking technologies.

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### TECHNICAL BACKGROUND

In computer-assisted medical procedures and surgical interventions, practitioners  
20 and surgeons use instruments and devices which are specifically adapted to be  
tracked by a medical navigation system. The relative position of these instruments  
can therefore be determined with respect to a patient's anatomy, wherein the  
instrument's spatial position (spatial location and/or spatial orientation) with respect  
to an image representation of the patient's anatomy is shown to the practitioner or  
25 surgeon via a display. It is common for trackable instruments and devices to include  
a specific type of tracking marker which is spatially recognized by a corresponding  
medical tracking system. A change in the tracking technology and even a change in  
the instrument's use case requiring a different tracking technology therefore requires  
entirely new instruments and devices to be developed and approved.

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The present invention has the object of providing a universal tracking marker  
interface which allows instruments and devices to be spatially tracked via a variety of  
different tracking technologies.

The present invention can be used for any medical and surgical procedures involving the use of medical tracking and navigation systems such as Curve® and Kick®, both products of Brainlab AG.

- 5 Aspects of the present invention, examples and exemplary steps and their embodiments are disclosed in the following. Different exemplary features of the invention can be combined in accordance with the invention wherever technically expedient and feasible.

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## **EXEMPLARY SHORT DESCRIPTION OF THE INVENTION**

- In the following, a short description of the specific features of the present invention is given which shall not be understood to limit the invention only to the features or a  
15 combination of the features described in this section.

- The present invention provides a tracking marker interface including a first and a second interface component which connect to each other in a releasable and statically determined manner. In particular, the interface components are adapted to  
20 connect to each other in a reproducible manner, which means that corresponding first and second interface components will, as soon as they connect to each other, always take the identical relative position with respect to each other.

## **25 GENERAL DESCRIPTION OF THE INVENTION**

In this section, a description of the general features of the present invention is given for example by referring to possible embodiments of the invention.

- 30 In general, the invention reaches the aforementioned object by providing, in a first aspect, a tracking marker interface comprising a first interface component and a second interface component adapted to releasably and rigidly engage each other in a statically determined manner and via corresponding first positioning sections, corresponding second positioning sections and corresponding fixation sections,

which are respectively assigned to the first interface component and to the second interface component. In this context, statically determined means that the first and second interface components connect to each other in a manner without “forcing” the interface components into place, which may result in elastic deformations of one or both interface components. In particular, the first and second interface components are adapted to connect to each other with (exactly) all six degrees of freedom (three rotational degrees of freedom and three translational degrees of freedom within the three dimensional space) being determined. For example, assuming the interface components experience different thermal expansions, which may result from one of the interface components expanding faster and/or by a higher amount when being exposed to an increase of temperature, none of the interface components will undergo a constraining stress because of how the interface components connect to each other. This will be described in more detail below.

According to the invention, the first and the second interface component are adapted to be brought into contact with each other and separated from each other substantially along a first spatial axis. The corresponding fixation sections are further adapted to prevent the first and the second interface components from being separated from each other. In other words, the interface components are brought into contact with each other by a translational motion substantially along a first spatial axis, wherein no additional rotational or translational motion is necessary for bringing the interface components into contact with each other. The same applies for disconnecting and separating the interface components from each other.

Further, the corresponding first positioning sections are adapted to prevent a translational relative motion between the contacting first and second interface components along a second spatial axis perpendicular to the first spatial axis, and to allow for a translational relative motion between the contacting first and second interface components along a third spatial axis perpendicular to the first spatial axis and to the second spatial axis, wherein the corresponding second positioning sections are adapted to prevent a translational relative motion between the contacting first and second interface components along the third spatial axis, and to allow for a translational relative motion between the contacting first and second interface components along the second spatial axis. It becomes apparent that it is the

first and the second positioning sections of the first and the second interface component, respectively, which ensure that the first and the second interface components connect to each other in the above described statically determined manner. In this regard, each one of a first positioning sections and the second  
5 positioning sections prevent, when the interface components connect to each other, one translational relative motion between the interface components, wherein the directions of these translational motions extend perpendicularly to each other as well as to the direction in which a translational relative motion between the interface components is prevented by the fixation sections. As each one of the first positioning  
10 sections, the second positioning sections and the fixation sections prevent a translational motion along one of a total of three spatial directions, any translational motion of the interface components is prevented once the interface components connect to each other. In this regard, it should be noted that the fixation sections, the first positioning sections and the second positioning sections prevent for a  
15 translational motion in one spatial direction only so as to prevent constraint stress and to allow for a statically determined connection between the interface components. It will be understood that any rotational motion between the interface components may also be prevented by the fixation sections, the first positioning sections and the second positioning sections being spaced apart from each other.  
20 Still, any one of the fixation sections, the first positioning sections and the second positioning sections may as such be adapted or formed to prevent a rotational motion of the first and second interface components with respect to each other.

For example, at least one of the first and second positioning sections of one of the  
25 first interface component and second interface component is shaped as a protrusion protruding from the interface component substantially along the first spatial axis, and wherein at least one of the first and second positioning sections of the other of the first interface component and second interface component is shaped as a recess substantially extending along the first spatial axis. In other words, any of the  
30 corresponding first and second positioning sections may be shaped as a male-female-pairing, wherein one of the positioning sections receives the corresponding other positioning section. In this regard, the corresponding positioning sections may comprise correspondingly shaped surfaces which may generally allow for an areal contact of the corresponding positioning sections. It is however also conceivable that

the corresponding positioning sections are shaped to substantially allow for one or more “linear contacts” between the corresponding positioning sections. This means that the corresponding positioning sections are generally shaped to physically connect to each other along one or more lines across the positioning section’s respective surfaces. For example, these one or more contact lines may extend along the spatial direction in which the respective positioning sections allow for a translational motion between the interface components.

In a more specific example, the protrusion mentioned above comprises at least one convex, particularly cylindrically shaped surface section and/or the recess comprises at least one concave or prismatically shaped surface section. In case the corresponding positioning sections are represented by a convex protrusion and a concave recess having the same curvature, one can easily imagine that the corresponding positioning sections may contact each other substantially across an areal surface area. A difference in the curvature of the recess and the curvature of the protrusion may result in the corresponding positioning sections contacting each other along one or more lines. The same would be the case if one of the recess and the protrusion includes a curved surface, for example a cylindrical surface, whilst the other of the recess and the protrusion includes a prismatically shaped surface, i.e. includes a plurality of flat surface sections adjoining each other at an angle.

In general, each one of the first positioning sections and the second positioning sections may include rail-shaped protrusions and/or correspondingly shaped grooves extending along the spatial direction in which the respective positioning sections allow for a translational relative motion between the interface components.

For example, the first positioning section of one of the first interface component and second interface component includes, particularly consists of two protruding surface sections which extend coaxially and substantially along the second spatial axis, particularly which extend from the interface component in substantially opposite directions. In a further example, any of the rail-shaped protrusion and the groove-shaped recess may be interrupted by any conceivable intermediate structure, resulting in respectively shaped end-sections which however have the same functionality as an uninterrupted rail or groove.

In another example, the second positioning section of one of the first interface component and second interface component includes, particularly consists of one protruding surface section, which extends substantially perpendicularly to the surface section(s) of the first positioning section, specifically along a plane perpendicular to the first spatial axis and defined by the surface section(s) of the first positioning section. From this specific example, it becomes apparent that the first and the second positioning sections are formed by rail-groove-pairings which extend perpendicularly to each other. Thus, the translational motion between the interface components which would be allowed for by one of the positioning sections is prevented by the respective other positioning section, and vice versa, thereby allowing for a statically determined connection between the interface components. In this regard, it further needs to be noted that the first and the second positioning sections do not necessarily extend along or within the same plane, but may also extend along or within parallel planes, both of which may be perpendicular to the first spatial axis.

Further, the fixation section of one of the first interface component and second interface component is configured to engage with a corresponding fixation section of the other of the first interface component and second interface component via a friction fit and/or via a form fit. In this regard, any conceivable friction-fit or form-fit connection is conceivable for releasably couple the interface components to each other. For example, one of the interface components may include a threaded hole or bore for receiving a threaded bolt of the other interface component, both of which may extend along the first spatial axis. Additionally or alternatively, the interface components may include respective parts of a snap-in-connection, with one or both corresponding fixation sections being elastically deformable. As will be described further below, the interface components may comprise more than one fixation-section-pairing, for example a thread connection and a snap-in-connection. This allows for connecting interface components of a different type, for example connecting an interface component made from metal to an interface component made from plastic. While it may be beneficial for an interface-component-pairing with both interface components being made from metal to have corresponding threaded fixation sections, an interface-components-pairing with both of the interface

components being made from plastic may benefit from a snap-in-type of fixation sections because of manufacturing reasons. If both or even more types of fixation sections is provided by the respective interface components, any conceivable pairing of interface components is conceivable, even if the interface components are of a different type.

In another, even more specific example, the fixation section of one of the first interface component and second interface component includes

- an internal thread adapted to engage with a screw assigned to the other of the first interface component and second interface component; and/or
- an elastically deformable snap-in connector adapted to engage with, particularly reach behind an edge of the other of the first interface component and second interface component; and/or
- a permanent magnet or electromagnet adapted to attract a corresponding permanent magnet, electromagnet or ferromagnetic element of the other of the first interface component and second interface component.

Further, one of the first interface component and the second interface component connects to, particularly is integrally formed with a tracking marker adapted to be recognized and spatially tracked by a medical tracking system, and the other of the first interface component and the second interface component connects to, particularly is integrally formed with a medical instrument or device.

In a still other example, at least one of the first interface component and the second interface component is made from plastic and/or is configured as disposable article to be distributed pre-sterilized. In particular, at least one of the first interface component and the second interface component is injection molded and particularly configured

- as undercut-free structure;
- to be molded in a slider-free injection-mold;
- to be molded in an injection-mold having one single unmolding direction; and/or
- to be demolded without elastic deformation.

Further, at least one of the first interface component and the second interface component is made from metal and/or is configured as reusable and sterilizable

article. In particular, at least one of the first interface component and the second interface component is machined, particularly involving a milling-process.

In a still other example, the tracking marker interface comprise corresponding key sections respectively assigned to the first interface component and to the second interface component, wherein the key sections are adapted to allow a predefined type of first interface component and second interface component to connect and to prevent another predefined type of first interface component and second interface component from connecting, particularly wherein the corresponding key sections are shaped to respectively allow or prevent engagement of the corresponding fixation sections. For example, this can be achieved by form-fit-features like a key-lock-feature (e.g. a pin and a hole at specific positions on the corresponding interface components). Additionally or alternatively, other features could be implemented in the software of a tracking system, which, for example, detects a tracking marker by its tracking geometry, a video detectable QR-code or a wireless ID such as an RFID-chip. In case it is detected that a first and a second interface component are about to be connected to each other but are not meant to be connected to each other for any reason, a medical tracking and navigation system may indicate to a user not to connect these interface components.

In another example, the tracking marker interface may further comprise corresponding signal- and/or power sections respectively assigned to the first interface component and to the second interface component, wherein the signal- and/or power sections are adapted to transmit signals and/or power between the first interface component and the second interface component. This would allow for using active tracking markers, for example light-emitting tracking markers or tracking markers including an EM-sensor to be used with the present invention. In this regard, it should again be noted that the present invention allows for conveniently using the same instruments and devices for different use cases which require different tracking technologies such as optical tracking, ultrasound tracking or EM (electromagnetic)-tracking. The present invention also allows for changing between different tracking technologies without changing the used instruments or devices. This is because the inventive tracking marker interface allows for simply swapping one tracking marker for another tracking marker relating to a different tracking technology. The first and

the second interface components may be adapted to allow for only one specific position in which the first and the second interface components can connect to each other.

- 5 A further aspect of the present invention relates to a tracking marker interface system comprising a plurality of first or second interface components according to any example set out above and at least one second or first interface component according to any example set out above, respectively, wherein the corresponding first positioning sections, the corresponding second positioning sections and the
- 10 corresponding fixation sections assigned to any of the plurality of first or second interface components and to the at least one second or first interface component, respectively, are adapted to connect to each other.

## 15 DEFINITIONS

In this section, definitions for specific terminology used in this disclosure are offered which also form part of the present disclosure.

## 20 Marker

- It is the function of a marker (i.e. tracking marker) to be detected by a marker detection device (i.e. tracking system, for example, a camera or an ultrasound receiver or analytical devices such as CT or MRI devices) in such a way that its
- 25 spatial position (i.e. its spatial location and/or alignment) can be ascertained. The detection device is for example part of a navigation system. The markers can be active markers. An active marker can for example emit electromagnetic radiation and/or waves which can be in the infrared, visible and/or ultraviolet spectral range. A marker can also however be passive, i.e. can for example reflect electromagnetic
- 30 radiation in the infrared, visible and/or ultraviolet spectral range or can block X-ray radiation. To this end, the marker can be provided with a surface which has corresponding reflective properties or can be made of metal in order to block the X-ray radiation. It is also possible for a marker to reflect and/or emit electromagnetic radiation and/or waves in the radio frequency range or at ultrasound wavelengths. A

marker preferably has a spherical and/or spheroid shape and can therefore be referred to as a marker sphere; markers can however also exhibit a cornered, for example cubic, shape.

## 5 **Marker array**

A marker array can for example be a reference star or a pointer or a single marker or a plurality of (individual) markers which are then preferably in a predetermined spatial relationship. A marker array comprises one, two, three or more markers, wherein two  
10 or more such markers are in a predetermined spatial relationship. This predetermined spatial relationship is for example known to a navigation system and is for example stored in a computer of the navigation system.

In another embodiment, a marker array comprises an optical pattern, for example on  
15 a two-dimensional surface. The optical pattern might comprise a plurality of geometric shapes like circles, rectangles and/or triangles. The optical pattern can be identified in an image captured by a camera, and the position of the marker array relative to the camera can be determined from the size of the pattern in the image, the orientation of the pattern in the image and the distortion of the pattern in the  
20 image. This allows determining the relative position in up to three rotational dimensions and up to three translational dimensions from a single two-dimensional image.

The position of a marker array can be ascertained, for example by a medical  
25 navigation system. If the marker array is attached to an object, such as a bone or a medical instrument, the position of the object can be determined from the position of the marker array and the relative position between the marker array and the object. Determining this relative position is also referred to as registering the marker array and the object. The marker array or the object can be tracked, which means that the  
30 position of the marker array or the object is ascertained twice or more over time.

## Marker Interface

5 A marker interface is understood to mean an attaching device for an individual marker which serves to attach the marker to an instrument, a part of the body and/or a holding element of a reference star, wherein it can be attached such that it is stationary and advantageously such that it can be detached. A marker interface can for example be rod-shaped and/or cylindrical. A fastening device (such as for instance a latching mechanism) for the marker interface can be provided at the end  
10 of the marker interface facing the marker and assists in placing the marker array on the marker interface in a force fit and/or positive fit.

## Pointer

15 A pointer is a rod which comprises one or more – advantageously, two – markers fastened to it and which can be used to measure off individual co-ordinates, for example spatial co-ordinates (i.e. three-dimensional co-ordinates), on a part of the body, wherein a user guides the pointer (for example, a part of the pointer which has a defined and advantageously fixed position with respect to the at least one marker  
20 attached to the pointer) to the position corresponding to the co-ordinates, such that the position of the pointer can be determined by using a surgical navigation system to detect the marker on the pointer. The relative location between the markers of the pointer and the part of the pointer used to measure off co-ordinates (for example, the tip of the pointer) is for example known. The surgical navigation system then enables  
25 the location (of the three-dimensional co-ordinates) to be assigned to a predetermined body structure, wherein the assignment can be made automatically or by user intervention.

## Reference star

30

A "reference star" refers to a device with a number of markers, advantageously three markers, attached to it, wherein the markers are (for example detachably) attached to the reference star such that they are stationary, thus providing a known (and advantageously fixed) position of the markers relative to each other. The position of

the markers relative to each other can be individually different for each reference star used within the framework of a surgical navigation method, in order to enable a surgical navigation system to identify the corresponding reference star on the basis of the position of its markers relative to each other. It is therefore also then possible  
5 for the objects (for example, instruments and/or parts of a body) to which the reference star is attached to be identified and/or differentiated accordingly. In a surgical navigation method, the reference star serves to attach a plurality of markers to an object (for example, a bone or a medical instrument) in order to be able to detect the position of the object (i.e. its spatial location and/or alignment). Such a  
10 reference star for example features a way of being attached to the object (for example, a clamp and/or a thread) and/or a interface/holding element which ensures a distance between the markers and the object (for example in order to assist the visibility of the markers to a marker detection device) and/or a marker interface which are mechanically connected to the interface/holding element and which the markers  
15 can be attached to.

### **Navigation system**

The present invention is also directed to a navigation system for computer-assisted  
20 surgery. This navigation system preferably comprises a computer for processing the data provided in accordance with the computer implemented method. The navigation system preferably comprises a tracking system, i.e. a detection device for detecting the position of detection points which represent the main points and auxiliary points, in order to generate detection signals and to supply the generated detection signals  
25 to the computer, such that the computer can determine the absolute main point data and absolute auxiliary point data on the basis of the detection signals received. A detection point is for example a point on the surface of the anatomical structure which is detected, for example by a pointer. In this way, the absolute point data can be provided to the computer. The navigation system also preferably comprises a user  
30 interface for receiving the calculation results from the computer (for example, the position of the main plane, the position of the auxiliary plane and/or the position of the standard plane). The user interface provides the received data to the user as information. Examples of a user interface include a display device such as a monitor, or a loudspeaker. The user interface can use any kind of indication signal (for

example a visual signal, an audio signal and/or a vibration signal). One example of a display device is an augmented reality device (also referred to as augmented reality glasses) which can be used as so-called "goggles" for navigating. A specific example of such augmented reality glasses is Google Glass (a trademark of Google, Inc.). An augmented reality device can be used both to input information into the computer of the navigation system by user interaction and to display information outputted by the computer.

### **Surgical navigation system**

A navigation system, such as a surgical navigation system, is understood to mean a system which can comprise: at least one marker array; a transmitter which emits electromagnetic waves and/or radiation and/or ultrasound waves; a receiver which receives electromagnetic waves and/or radiation and/or ultrasound waves; and an electronic data processing device which is connected to the receiver and/or the transmitter, wherein the data processing device (for example, a computer) for example comprises a processor (CPU) and a working memory and advantageously an indicating device for issuing an indication signal (for example, a visual indicating device such as a monitor and/or an audio indicating device such as a loudspeaker and/or a tactile indicating device such as a vibrator) and a permanent data memory, wherein the data processing device processes navigation data forwarded to it by the receiver and can advantageously output guidance information to a user via the indicating device. The navigation data can be stored in the permanent data memory and for example compared with data stored in said memory beforehand.

### **Fixed (relative) position**

A fixed position, which is also referred to as fixed relative position, in this document means that two objects which are in a fixed position have a relative position which does not change unless this change is explicitly and intentionally initiated. A fixed position is in particular given if a force or torque above a predetermined threshold has to be applied in order to change the position. This threshold might be 10 N or 10 Nm. In particular, the position of a sensor device remains fixed relative to a target while the target is registered or two targets are moved relative to each other. A fixed

position can for example be achieved by rigidly attaching one object to another. The spatial location, which is a part of the position, can in particular be described just by a distance (between two objects) or just by the direction of a vector (which links two objects). The alignment, which is another part of the position, can in particular be described by just the relative angle of orientation (between the two objects).

## BRIEF DESCRIPTION OF THE DRAWINGS

- 10 In the following, the invention is described with reference to the appended figures which give background explanations and represent specific embodiments of the invention. The scope of the invention is however not limited to the specific features disclosed in the context of the figures, wherein
- 15 Fig. 1 shows a surgical instrument along with different types of tracking markers featuring the inventive tracking marker interface,
- Fig. 2 shows a first embodiment of the inventive tracking marker interface,
- Fig. 3 shows a second embodiment of the inventive tracking marker interface,
- 20 Fig. 4 shows an injection molded interface component of the inventive tracking marker interface,
- Fig. 5 shows an interface component of a third embodiment of the inventive tracking marker interface, corresponding to the interface component shown in Fig. 4,
- 25 Fig. 6 shows a 3D view of the second interface component comprising an electrical connector for energy or data transmission,
- Fig. 7 shows the instrument of Fig. 1 along with a tracking marker connected to the instrument via the inventive tracking marker interface,
- 30 Fig. 8 shows further instruments and devices featuring a first interface component of the inventive tracking marker interface, and
- Fig. 9A/9B show further tracking markers featuring a second interface component of the inventive tracking marker interface.

## DESCRIPTION OF EMBODIMENTS

5 Figure 1 shows a pointer instrument 9 which is commonly used in surgical procedures for palpating objects and anatomical structures so as to determine their spatial position. While the pointer 9 includes a first interface component 1 being integrally formed with the pointer body, different types of tracking markers 8 provide a correspondingly shaped second interface component 2 adapted to releasably  
10 connect to the first interface component 1.

Figure 2 provides a more detailed view on a first interface component 1 and a second interface component 2 which are adapted to releasably and rigidly interlock in a statically determined manner. In the shown example, both of the first interface  
15 component 1 and second interface component 2 may be made from a metallic material and may therefore represent milled components. The first interface component 1 comprises two first positioning sections 3A which protrude in opposing directions from a central structure of the interface component 1, both of which have a cylindrical contact surface. Further, a second positioning section 4A also having a  
20 cylindrical contact surface is provided at a more distal position of the interface component 1. The correspondingly shaped second interface component 2 includes two first positioning sections 3B and one second positioning section 4B, all of which are formed as cylindrically shaped recesses for receiving the positioning sections 3A and 3B of the first interface component 1. Once the first interface component 1 and  
25 the second interface component 2 have been brought into engagement with each other, with the corresponding positioning sections 3A, 3B, 4A and 4B contacting each other, the second interface component 2 can be fastened to the first interface component 1 via a threaded bolt 5B screwed into the threaded bore 5A of the first interface component 1.

30

From Figure 2 it becomes apparent that, within the plane spanned by the directions X and Y, the pairing of the first positioning sections 3A and 3B as well as the pairing of the second positioning sections 4A and 4B allow for one translational motion between the interface components 1 and 2, while this motion is prevented by the

respective other pairing. Further, a relative motion along the Z-direction is prevented by the fixation sections, i.e. the threaded bolt 5B engaging with the threaded hole 5A. As the positioning sections 3A, 3B, 4A and 4B are spaced apart from each other, any rotational relative motion between the interface components 1 and 2 is also prevented. As a result, all six degrees of freedom between the first interface component 1 and the second interface component 2 are set in a statically determined manner. For disconnecting the tracking marker 8 from the instrument 9, bolt 5B is unscrewed from hole 5A such that the second interface component 2 can be released from the first interface component 1.

The embodiment shown in Figure 3 has the same functionality as the embodiment shown in Figure 2. The fixation sections 5B are however represented by tabs (cf. Figure 5) formed at the second interface component 2, each of which comprises a hooked protrusion adapted to snap into correspondingly formed recesses 5A at the first interface component 1. While the first interface component 1 of Figures 1, 2 and 3 may be formed from a metallic material in a milling process, the second interface component 2 of Figure 3 is a injection-molded-product made from a plastic material. Therefore, the tabs 5B can deform elastically and may therefore deflect while the second interface component 2 is pressed onto the first interface component 1 until the hook-shaped protrusions of tabs 5B snap into the recesses 5A, thereby holding the interface components 1 and 2 firmly together.

The first interface component 1 shown in Figure 4 has the same functionality as the first interface components 1 shown in Figures 2 and 3. It is however formed as a injection-molded-product made from a plastic material.

Figure 5 shows a 4-side-view of the injection-molded second interface component 2 of Figure 3.

Figure 6 shows another embodiment of a second interface component 2 which additionally comprises a signal- and/or power-section 7A, 7B that provides a plurality of electrical contacts for transmitting electric power and/or signals to and/or from an electromagnetic (EM)-sensor 8 to be used in conjunction with an EM-tracking-

system. In the embodiment shown in Figure 6, no fixation sections 5A and 5B are shown for the sake of clarity of presentation.

5 Figure 7 shows the pointer instrument of Figure 1 along with a planar (2D-)tracking marker 8, both of which interconnect via the tracking marker interface according to the present invention.

10 The inventive tracking marker interface can be used for any conceivable instrument or device the spatial position of which needs to be determined during a medical or surgical procedure, a selection of which is shown in Figure 8. It needs to be noted that each one of the instruments and devices 9 shown in Figure 8 features a first interface component 1 that provides positioning sections 3A and 4A with the same geometry and relative position. Additionally, each one of the interface components also comprises one or more fixation section 5A and 5B as described herein. This  
15 allows for connecting a specific type of tracking marker 8 to any instrument or device featuring the first interface component 1. On the other hand, each of the various tracking markers 8 shown for example in Figure 1 and Figures 9A and 9B features a second interface component 2 providing the same first and second positioning sections 3B and 4B and at least one of the fixation sections 5B described herein.  
20 Thus, any of the tracking markers shown in Figures 1 or Figure 9A and 9B can be releasably attached to any of the instruments shown in Figure 1 and Figure 8.

5

**CLAIMS**

1. Tracking marker interface comprising a first interface component (1) and a second interface component (2) adapted to releasably and rigidly engage each other in a statically determined manner and via corresponding first positioning sections (3A, 3B), corresponding second positioning sections (4A, 4B) and corresponding fixation sections (5A, 5B) respectively assigned to the first interface component (1) and to the second interface component (2), wherein
- the first and the second interface component (1, 2) are adapted to be brought into contact with each other and separated from each other substantially along a first spatial axis (Z), and wherein the corresponding fixation sections (5A, 5B) are adapted to prevent the first and the second interface components (1, 2) from being separated from each other;
  - the corresponding first positioning sections (3A, 3B) are adapted to prevent a translational relative motion between the contacting first and second interface components (1, 2) along a second spatial axis (X) perpendicular to the first spatial axis (Z), and to allow for a translational relative motion between the contacting first and second interface components (1, 2) along a third spatial axis (Y) perpendicular to the first spatial axis (Z) and to the second spatial axis (X);
  - the corresponding second positioning sections (4A, 4B) are adapted to prevent a translational relative motion between the contacting first and second interface components (1, 2) along the third spatial axis (Y), and to allow for a translational relative motion between the contacting first and second interface components (1, 2) along the second spatial axis (X).
2. Tracking marker interface according to claim 1, wherein at least one of the first and second positioning sections (3A, 3B, 4A, 4B) of one of the first interface component (1) and second interface component (2) is shaped as a protrusion protruding from the interface component (1, 2) substantially along the first spatial axis (Z), and wherein at least one of the first and second positioning sections (3A, 3B, 4A, 4B) of the other of

the first interface component (1) and second interface component (2) is shaped as a recess substantially extending along the first spatial axis (Z).

3. Tracking marker interface according to claim 2, wherein the protrusion comprises  
5 at least one convex, particularly cylindrically shaped surface section and/or wherein the recess comprises at least one concave or prismatically shaped surface section.
4. Tracking marker interface according to one of the claims 1 to 3, wherein the first  
10 positioning section (3A, 3B) of one of the first interface component (1) and second interface component (2) includes, particularly consists of two protruding surface sections which extend coaxially substantially along the second spatial axis (Y), particularly which extend from the interface component (1, 2) in substantially opposite directions.
- 15 5. Tracking marker interface according to one of the claims 1 to 4, wherein the second positioning section (4A, 4B) of one of the first interface component (1) and second interface component (2) includes, particularly consists of one protruding surface section, which extends substantially perpendicular to the surface section(s) of the first positioning section (3A, 3B), particularly along a plane perpendicular to the  
20 first spatial axis (Z) and defined by the surface section(s) of the first positioning section (3A, 3B).
6. Tracking marker interface according to one of the claims 1 to 5, wherein the  
25 fixation section (5A, 5B) of one of the first interface component (1) and second interface component (2) is configured to engage with a corresponding fixation section (5A, 5B) of the other of the first interface component (1) and second interface component (2) via a friction fit and/or via a form fit.
7. Tracking marker interface according to claim 6, wherein the fixation section (5A,  
30 5B) of one of the first interface component (1) and second interface component (2) includes
  - an internal thread adapted to engage with a screw assigned to the other of the first interface component (1) and second interface component (2); and/or

- an elastically deformable snap-in connector adapted to engage with, particularly reach behind an edge of the other of the first interface component (1) and second interface component (2); and/or

- 5     - a permanent magnet or electromagnet adapted to attract a corresponding permanent magnet, electromagnet or ferromagnetic element of the other of the first interface component (1) and second interface component (2).

10    8. Tracking marker interface according to any one of claims 1 to 7, wherein one of the first interface component (1) and the second interface component (2) connects to, particularly is integrally formed with a tracking marker (8) adapted to be recognised and spatially tracked by a medical tracking system, and the other of the first interface component (1) and the second interface component (2) connects to, particularly is integrally formed with a medical instrument (9) or device.

15    9. Tracking marker interface according to any one of claims 1 to 8, wherein at least one of the first interface component (1) and the second interface component (2) is made from plastic and/or is configured as disposable article to be distributed pre-sterilized.

20    10. Tracking marker interface according to any one of claims 1 to 8, wherein at least one of the first interface component (1) and the second interface component (2) is made from metal and/or is configured as reusable and sterilizable article.

25    11. Tracking marker interface according to any one of claims 1 to 10, wherein at least one of the first interface component (1) and the second interface component (2) is injection molded and particularly configured

- 30     - as undercut-free structure;  
      - to be molded in a slider-free injection-mold;  
      - to be molded in an injection-mold having one single unmolding direction; and/or  
      - to be demolded without elastic deformation.

12. Tracking marker interface according to any one of claims 1 to 10, wherein at least one of the first interface component (1) and the second interface component (2) is machined, particularly involving a milling-process.

13. Tracking marker interface according to any one of claims 1 to 12, further comprising corresponding key sections respectively assigned to the first interface component (1) and to the second interface component (2), wherein the key sections are adapted to allow a predefined type of first interface component (1) and second interface component (2) to connect and to prevent another predefined type of first interface component (1) and second interface component (2) to connect, particularly wherein the corresponding key sections are shaped to respectively allow or prevent engagement of the corresponding fixation sections (5A, 5B).

14. Tracking marker interface according to any one of claims 1 to 13, further comprising corresponding signal- and/or power sections (7A, 7B) respectively assigned to the first interface component (1) and to the second interface component (2), wherein the signal- and/or power sections (7A, 7B) are adapted to transmit signals and/or power between the first interface component (1) and the second interface component (2).

15. Tracking marker interface system comprising a plurality of first or second interface components (1, 2) according to any one of claims 1 to 14 and at least one second or first interface component (1, 2) according to any one of claims 1 to 14, respectively, wherein the corresponding first positioning sections (3A, 3B), the corresponding second positioning sections (4A, 4B) and the corresponding fixation sections (5A, 5B) assigned to any of the plurality of first or second interface components (1, 2) and to the at least one second or first interface component (1, 2), respectively, are adapted to connect to each other.

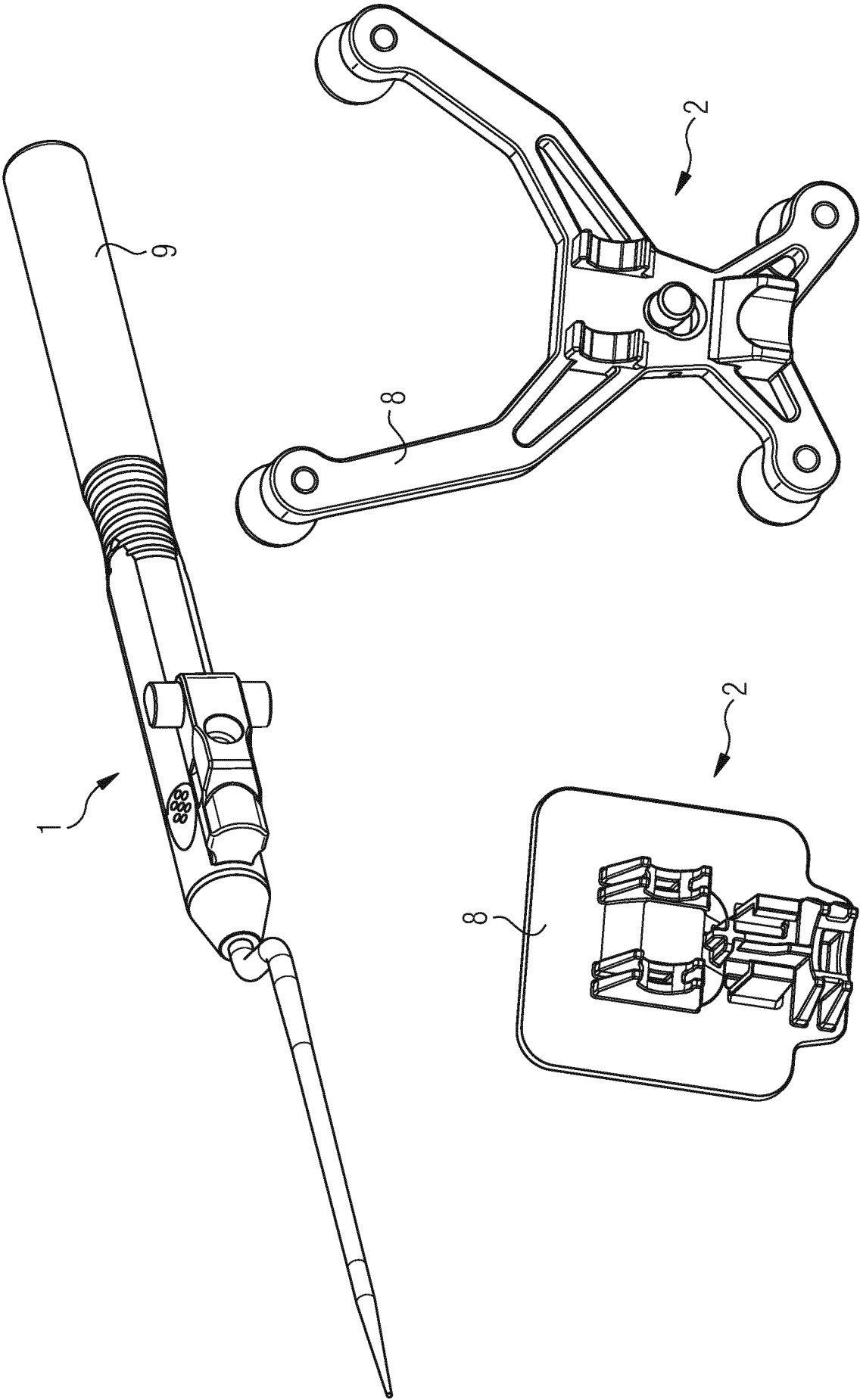


FIG. 1

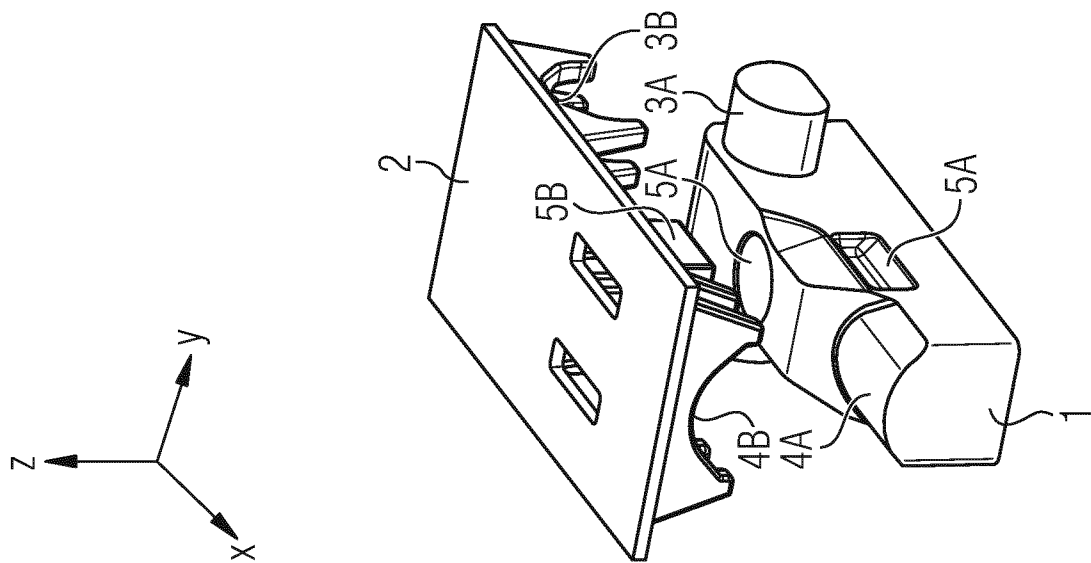


FIG. 2

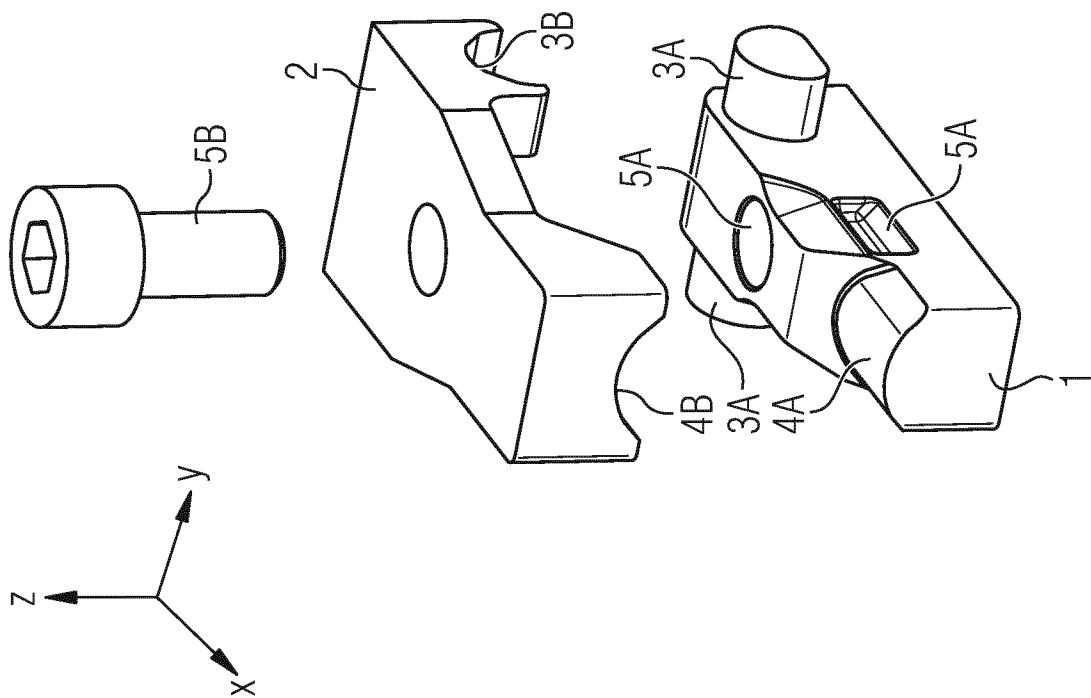


FIG. 3

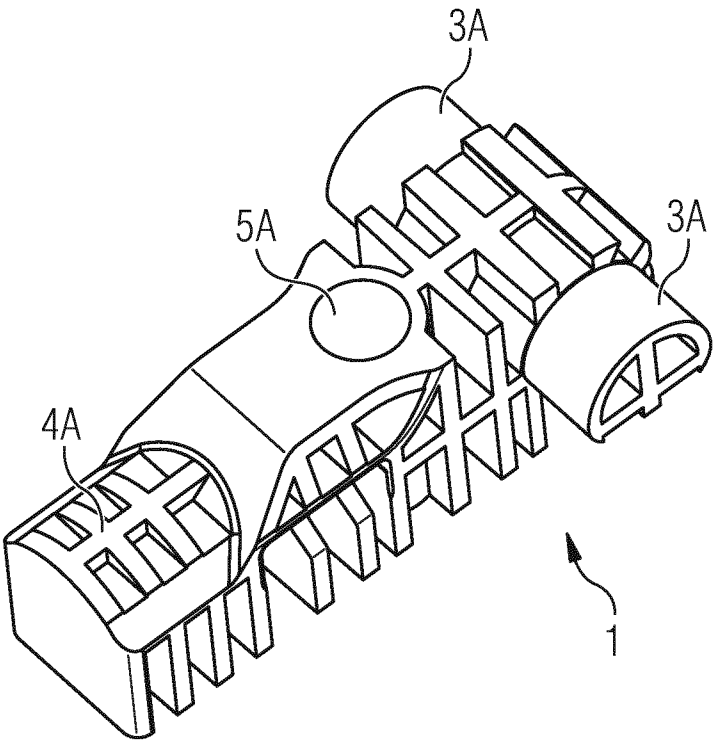


FIG. 4

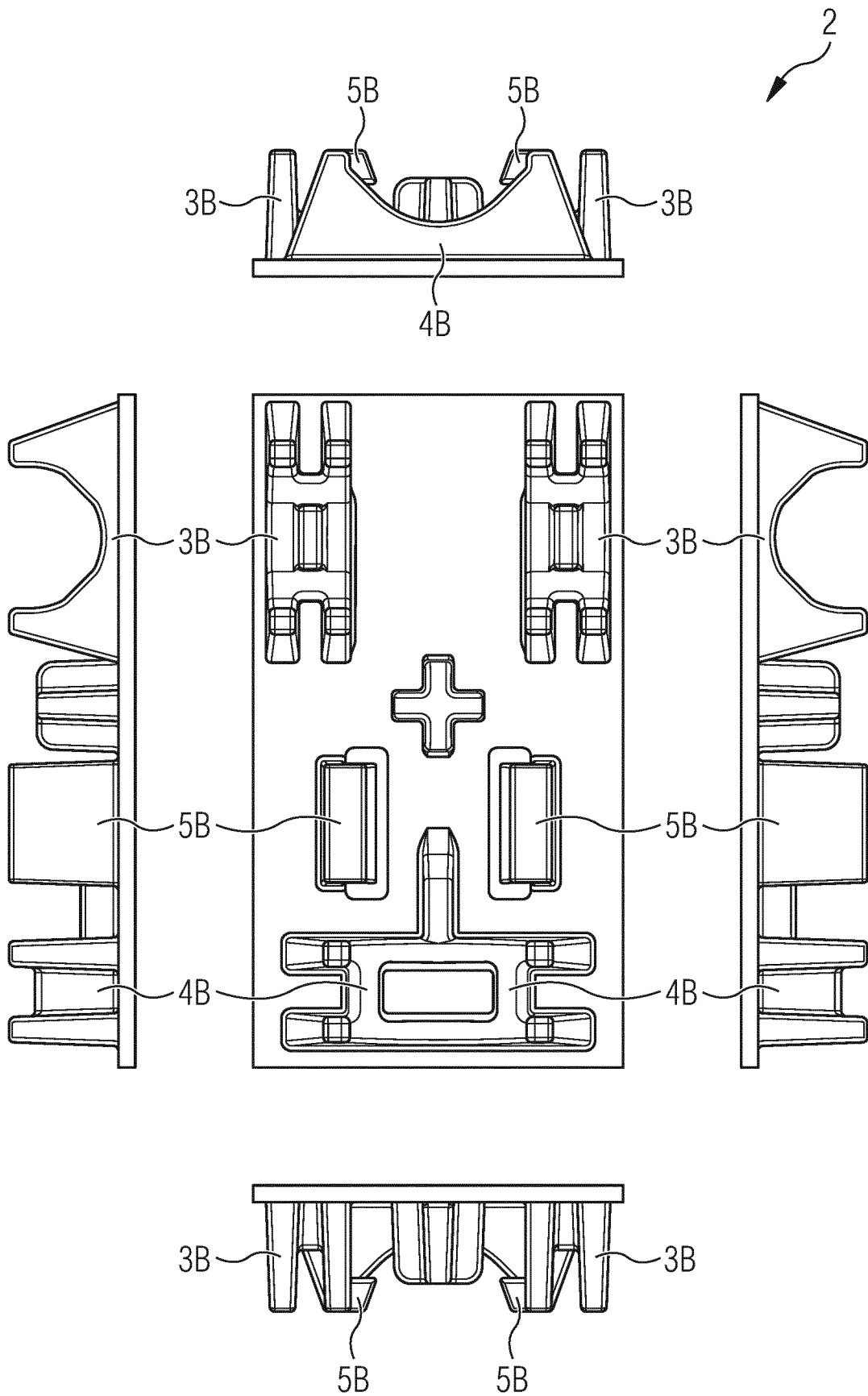


FIG. 5

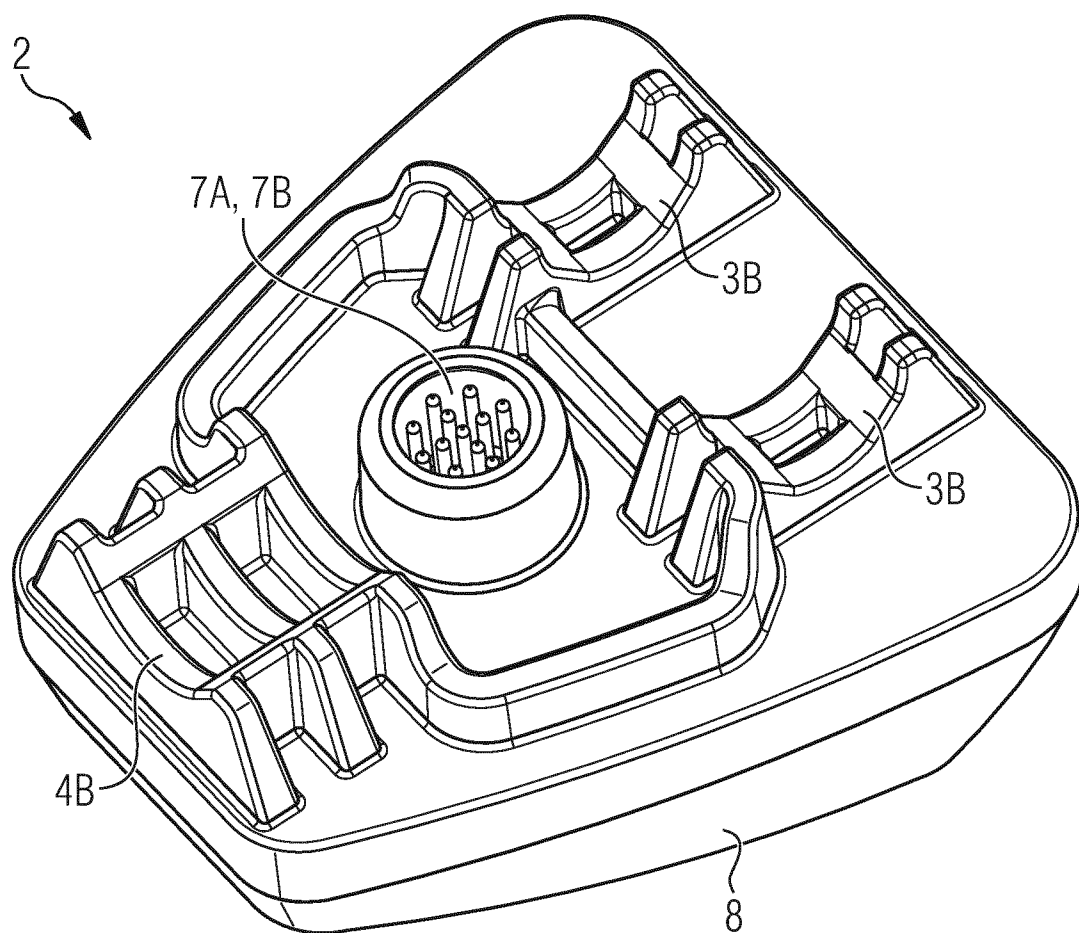


FIG. 6

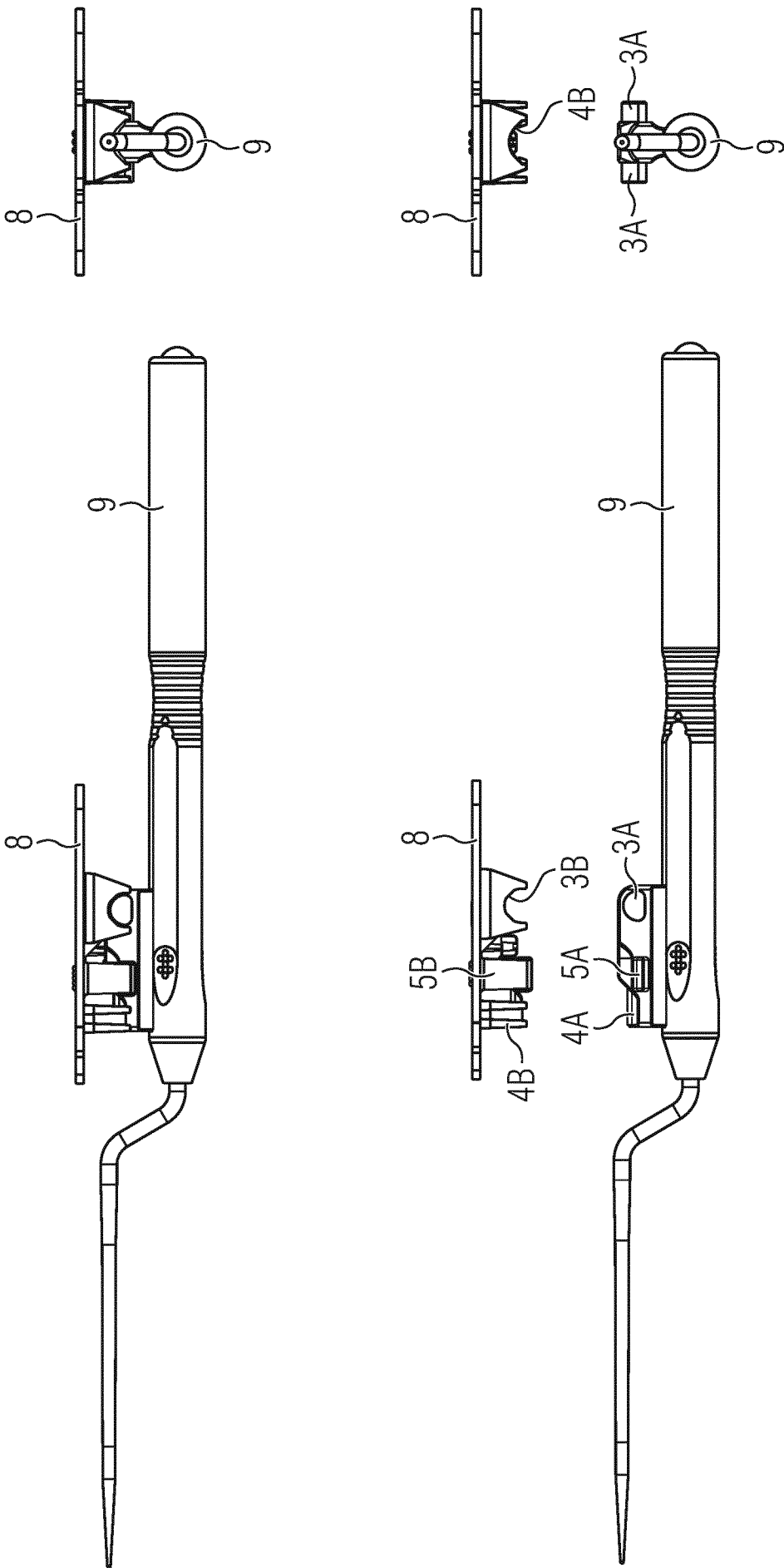


FIG. 7

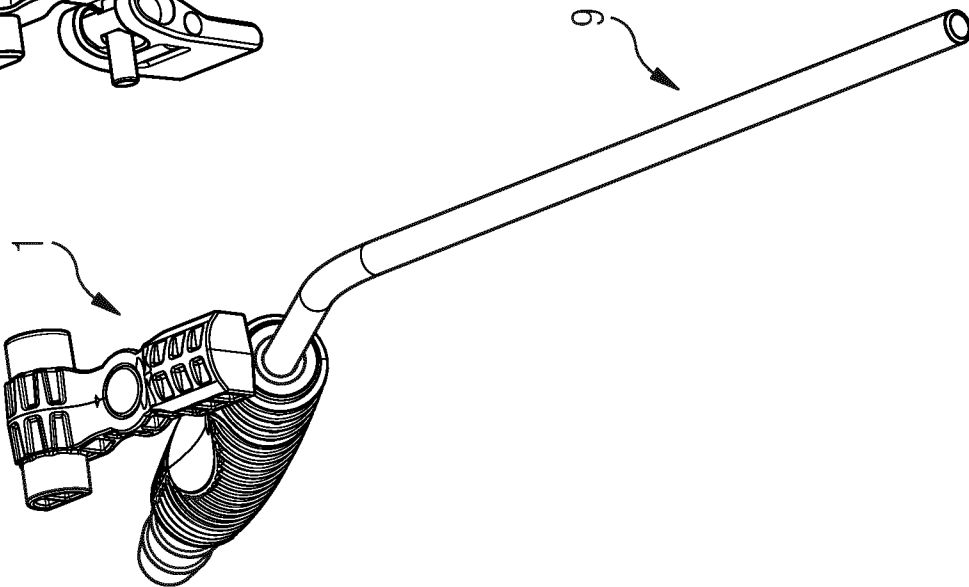
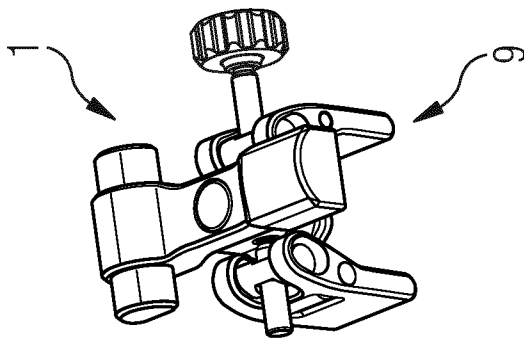
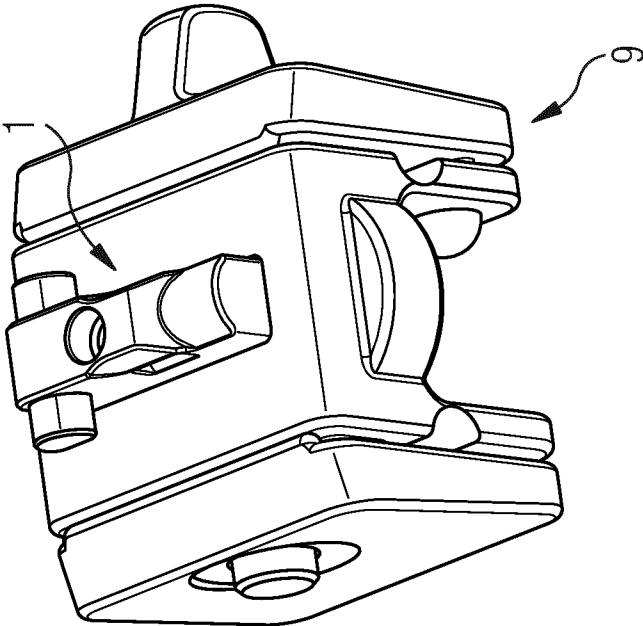


FIG. 8

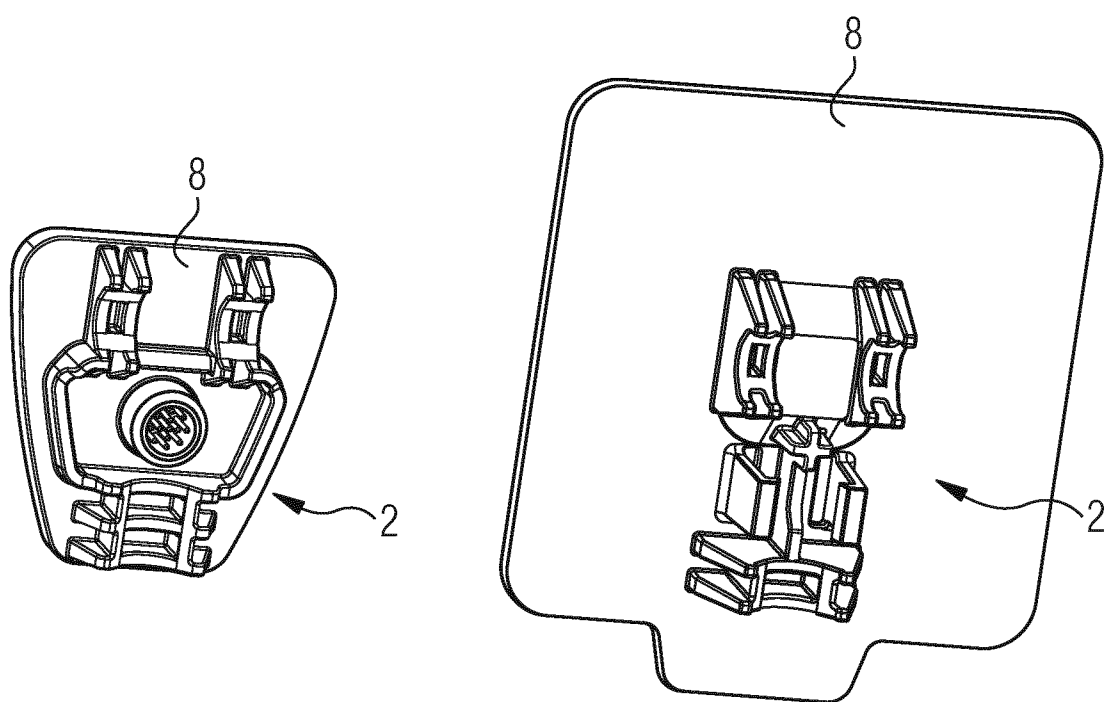


FIG. 9A

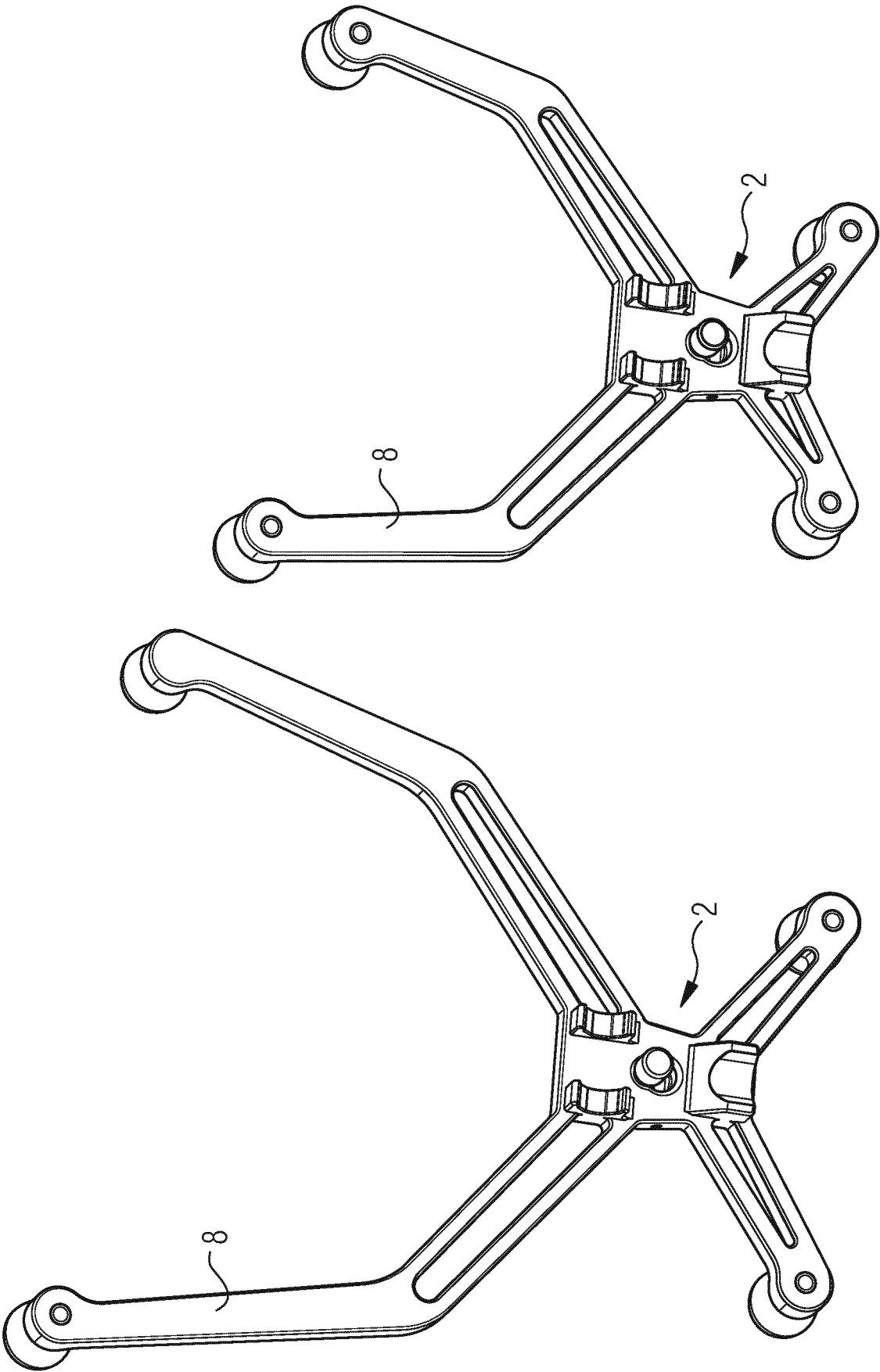


FIG. 9B

## INTERNATIONAL SEARCH REPORT

International application No  
**PCT/EP2023/084145**

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                                                                                                                                     |                                                                         |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------|
| <b>A. CLASSIFICATION OF SUBJECT MATTER</b><br><b>INV. A61B90/00 A61B17/00 A61B34/20</b><br><b>ADD.</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                                                                                                                                     |                                                                         |
| According to International Patent Classification (IPC) or to both national classification and IPC                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                                                                                                                                     |                                                                         |
| <b>B. FIELDS SEARCHED</b><br>Minimum documentation searched (classification system followed by classification symbols)<br><b>A61B</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                                                                                                                                     |                                                                         |
| Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                                                                                                                     |                                                                         |
| Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)<br><b>EPO-Internal</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                                                                                                                                     |                                                                         |
| <b>C. DOCUMENTS CONSIDERED TO BE RELEVANT</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                                                                                                                     |                                                                         |
| Category*                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | Citation of document, with indication, where appropriate, of the relevant passages                                                                  | Relevant to claim No.                                                   |
| <b>A</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | <b>US 2023/047595 A1 (ELSAWAH LAMIS [US] ET AL) 16 February 2023 (2023-02-16) figures 1-6 paragraph [0028] - paragraph [0069]</b><br>-----          | <b>1-15</b>                                                             |
| <b>A</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | <b>US 2012/168587 A1 (KARSAK OEZCAN [DE] ET AL) 5 July 2012 (2012-07-05) figures 3-31 paragraph [0060] - paragraph [0106]</b><br>-----              | <b>1-15</b>                                                             |
| <b>A</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | <b>US 2008/200794 A1 (TEICHMAN ROBERT [US] ET AL) 21 August 2008 (2008-08-21) figures 1-11 paragraph [0038] - paragraph [0061]</b><br>-----<br>-/-- | <b>1-15</b>                                                             |
| <input checked="" type="checkbox"/> Further documents are listed in the continuation of Box C. <input checked="" type="checkbox"/> See patent family annex.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                                                                                                                                                     |                                                                         |
| <p>* Special categories of cited documents :</p> <p>"A" document defining the general state of the art which is not considered to be of particular relevance</p> <p>"E" earlier application or patent but published on or after the international filing date</p> <p>"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)</p> <p>"O" document referring to an oral disclosure, use, exhibition or other means</p> <p>"P" document published prior to the international filing date but later than the priority date claimed</p> <p>"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</p> <p>"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</p> <p>"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</p> <p>"&amp;" document member of the same patent family</p> |                                                                                                                                                     |                                                                         |
| Date of the actual completion of the international search<br><b>14 May 2024</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                                                                                                                                     | Date of mailing of the international search report<br><b>24/05/2024</b> |
| Name and mailing address of the ISA/<br>European Patent Office, P.B. 5818 Patentlaan 2<br>NL - 2280 HV Rijswijk<br>Tel. (+31-70) 340-2040,<br>Fax: (+31-70) 340-3016                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                                                                                                                     | Authorized officer<br><b>Bocage, Stéphane</b>                           |

## INTERNATIONAL SEARCH REPORT

International application No

PCT/EP2023/084145

| C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT |                                                                                                                                         |                       |
|------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------|-----------------------|
| Category*                                            | Citation of document, with indication, where appropriate, of the relevant passages                                                      | Relevant to claim No. |
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| A                                                    | US 2015/297315 A1 (FOWLER MARIA [DE] ET AL) 22 October 2015 (2015-10-22)<br>figures<br>paragraph [0050] - paragraph [0061]<br>-----     | 1-15                  |

# INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/EP2023/084145

| Patent document<br>cited in search report | Publication<br>date | Patent family<br>member(s)                                                                                                         | Publication<br>date                                                                            |
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