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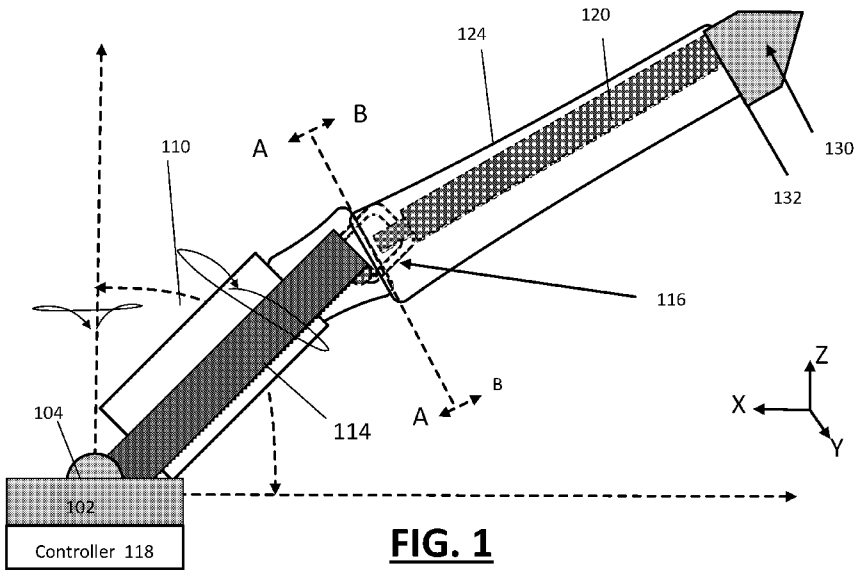

FIG. 1

(57) Abstract: A mechanical arm assembly having a base extension, at least one motor, an arm extension, and a joint. A motor operates to rotate a first interior member of the base extension while the first interior member is received by the joint, causing (i) a second interior member of the arm extension to rotate, and (ii) a face of the second exterior shell to rotate about a face of the first exterior shell.

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CONIC ARM JOINT

RELATED APPLICATIONS

[0001] This application claims the benefit of U.S. Provisional Patent Application No. 62/135,108 filed March 18, 2016; the aforementioned priority application being hereby incorporated by reference in its entirety.

BRIEF DESCRIPTION OF THE DRAWINGS

[0002] FIG. 1 illustrates an example mechanical arm assembly according to one or more embodiments.

[0003] FIG. 2A and FIG. 2B illustrate example cross-sectional views along lines A-A and B-B respectively.

[0004] FIG. 3A and FIG. 3B illustrate an alternative implementation of an arm assembly described with an example of FIG. 1.

[0005] FIG. 4A and FIG. 4B illustrate examples in which gears are used to facilitate coupling between the base extension and the base coupling, as well as between the base extension and the arm extension.

[0006] FIG. 5 illustrates a food preparation device, according to one or more embodiments.

DETAILED DESCRIPTION

[0007] Examples include a mechanical arm assembly having a base extension, at least one motor, an arm extension, and a joint. The base extension includes a first interior member and a second exterior shell. The motor is coupled to move the first interior member so that the first interior member has three degrees of freedom. The arm extension extends from the base extension, and includes a second interior member

and a second exterior shell. The joint may couple the first interior member to the second interior member, the joint including a first end to receive the first interior member and a second end to receive the second interior member. The base extension, the arm extension, and the joint may combine to position a face of the first exterior shell against a face of the second exterior shell. The motor operates to rotate the first interior member while the first interior member is received by the joint, causing (i) the second interior member to rotate, and (ii) the face of the second exterior shell to rotate about the face of the first exterior shell.

[0008] FIG. 1 illustrates an example mechanical arm assembly according to one or more embodiments. An arm assembly 100 includes a base 102, a base coupling 104, a base extension 110 that is connected to the base 102 via the base coupling 104, and an arm extension 120, which is coupled to the base extension 110 via a joint 116. The base extension 110 may have three degrees of freedom. In particular, the base extension 110 may pivot about the X and Y axis and further rotate about an azimuth while vertical or tilted. According to some examples, the coupling 104 is a motorized gimbal that can pivot and rotate the base extension 110. The base coupling 104 may operate under control of a controller 118, which may calculate the movement of the base extension 110 on a desired end movement of either the arm extension 120 or of an extension piece 130. As described in greater detail, the active motor-driven movement of the base extension 110 results in indirect or passive movement of the arm extension 120.

[0009] In some examples, the arm extension 120 is coupled to have one degree of freedom about the joint 116. For example, the joint 116 may correspond to a U-joint. In this respect, three-dimensional movement of the base extension 110 results in ancillary (e.g., by way of conservation of momentum) movement of the arm extension 120.

[0010] In some examples, the base extension 110 and 120 include a respective first and second exterior shell 114, 124. In some variations, the exterior shell 114 of the base extension 110 may be fixed relative to the base or base coupling, to that rotation of the base extension 110 does not directly (or even indirectly) result in movement of the first exterior shell 114. Conversely, the second external shell 124 can be tied to the arm extension 120 so as to rotate when the arm extension 120 is rotated.

[0011] In some examples, the base extension 110 and arm extension 120 combine to form a conical connection or joint, through the mechanical interface between the respective exterior shells 114, 124. In one implementation, the first exterior shell 114 includes a first exterior face 202 (see FIG. 2A) and the second exterior shell 124 includes a second exterior face 204 (see FIG. 2B). The first and second exterior faces 202, 204 of the respective exterior shells 114, 124 abut and move against one another as the base extension 110 is moved by the coupling 104. The abutting and movement of the first and second exterior faces 202 and 204 forms a conical joint with the joint 116.

[0012] The base coupling 104 may be electrically coupled to a controller 118, which can implement movement of the base extension 110 in order to create a desired motion of the arm extension 120 and/or extension piece 130. In some implementations, the extension piece 130 is replaceable, being connected via a mechanical attachment interface 132. The controller 118 may be instructed to cause the extension piece 130 to have a motion that is selected for a purpose or structure of the extension piece 130.

[0013] In some examples, the base extension 110 and/or the arm extension 120 includes a set of sensors and/or encoder system to detect and measures angles of the arm assembly 100 (or of additional joints if used). By way of examples, the encoders may be contactless (e.g. optical, hall effect), rotational (e.g. rotary encoders), or rotation-limited

(e.g. potentiometers). Still further, the encoders may be mounted close to the moving part of the arm assembly 100, or mounted on the drive shaft, gearing, pulleys, or other drive system supplying energy to the joint. The encoders may be built into the drive motor, or attached to the drive system of the joint via secondary gear, pulley, drive shaft, or other drive system.

[0014] One or more components of the arm assembly 100 may also be used as part of a sensing system that observes changes to the joint, such as a camera, vision system, infrared camera, or other range or motion tracking system. In variations, the arm assembly 100 may employ a visual artifact (e.g. an AR tag) to assist in determining position and orientation of the base extension 110 and/or the arm extension 120. Still further, the arm assembly 100 may employ a set of markers designed to make detection by the observer system easier or more reliable; or may be colored or styled in a way that makes detection easier or more reliable (e.g. stripes, patterns, bright colors, colors at certain points in the spectrum, etc.).

[0015] FIG. 2A and FIG. 2B illustrate example cross-sectional views along lines A-A and B-B respectively. In FIG. 2A, a cross-section 205 of the base extension 110 is shown with the base extension 110 provided within the first external shell 114. The first external shell 114 includes the first exterior face 202, which abuts against the second exterior face 204 in order to cause the arm extension 120 to have a motion that is indirectly related to the three-dimensional movement of the base extension 110. In an example of FIG. 2A, the base extension 110 is not directly coupled to the first external shell 114. As a result, the base extension 110 may rotate without causing the first external shell 114 to rotate.

[0016] In FIG. 2B, a cross-section 215 of the arm extension 120 is shown with the arm extension 120 provided within the second external

shell 124. The second external shell 124 includes the second exterior face 204, which abuts the first exterior face 202. The arm extension 120 and the second external shell 124 may be directly connected. The arm extension 120 may be received by the joint 116, and the joint 116 may rotate as a result of receiving the base extension 110. When the joint 116 rotates, the arm extension 120 also rotates by way of the indirect coupling via the joint 116. The rotation of the arm extension 120 causes the second external shell 124 to rotate as well.

[0017] In operation, the joint 116 may revolve about an axis that is tilted with respect to the vertical axis depicted in FIG. 1. A tilt angle may be defined by the angle of the base extension 110 relative to the vertical axis.

[0018] FIG. 3A and FIG. 3B illustrate an alternative implementation of an arm assembly described with an example of FIG. 1. In FIG. 3A, the base extension 310 extends to the arm extension 320 at a first angle. In FIG. 3B, the arm extension 320 is provided at a 90 degree angle with respect to the base extension 310.

[0019] Among other benefits, examples as shown enable the extension piece 130 is allowed to have a wider range of motion with fewer degrees of freedom on the arm or joint. Moreover, the arm assembly may allow for very motions with fewer inputs than other conventional approaches (e.g., prismatic joints).

[0020] As an alternative or variation, FIG. 4A and FIG. 4B illustrate examples in which gears 410, 412 are used to facilitate coupling between the base extension 110 and the base coupling, as well as between the base extension and the arm extension.

[0021] A co-conic arm design may be capable of simple mixing motions. Simple mixing motions may involve moving a spatula around a pot in a circle, sinusoid, zig zag, or other periodic repeating pattern.

[0022] Examples as described may enable numerous complex motions, which may be electronically controllable via one or more motors. Such motions may also be influenced by the arm geometry; or by the spatula or paddle or other manipulator attached to the end.

[0023] The arm assembly 100 may support various kinds of motions and movements, including graceful degradation from complex manipulation to simple mixing motions; this degradation may occur for many reasons, including motor malfunction, design malfunction, design choices, manipulator selection, etc. The arm design may allow for upgrades or changes in hardware, software, services, attachments, or other mechanisms to control, alleviate, or augment the degradation, or the normal functionality of the arm assembly.

[0024] FIG. 5 illustrates a food preparation device, according to one or more embodiments. A food preparation device 310 may include an arm assembly 300, which may be constructed in accordance with any of the examples described above, including with arm assembly 100 of FIG. 1. The arm assembly 300 can be operated through controller 118 (FIG. 1) to make any one of numerous possible motions and gestures related to mixing/distributing food items in a cooking environment. The end piece 130 may also be selected for alternative purposes (e.g., spatula or stirrer), which can affect the mixing motion used by the arm assembly 300.

[0025] Although illustrative embodiments have been described in detail herein with reference to the accompanying drawings, variations to specific embodiments and details are encompassed by this disclosure. It is intended that the scope of embodiments described herein be defined by claims and their equivalents. Furthermore, it is contemplated that a particular feature described, either individually or as part of an embodiment, can be combined with other individually described features, or parts of other embodiments. Thus, absence of describing combinations

should not preclude the inventor(s) from claiming rights to such combinations.

WHAT IS CLAIMED IS:

1. A mechanical arm assembly comprising:

a base extension, including a first interior member and a first exterior shell;

at least one motor coupled to move the first interior member so that the first interior member has three degrees of freedom;

an arm extension extending from the base extension, the arm extension including a second interior member and a second exterior shell;

a joint to couple the first interior member to the second interior member, the joint including a first end to receive the first interior member and a second end to receive the second interior member;

wherein the base extension, the arm extension, and the joint combine to position a face of the first exterior shell against a face of the second exterior shell;

wherein the at least one motor operates to rotate the first interior member while the first interior member is received by the joint, causing (i) the second interior member to rotate, and the face of the second exterior shell to rotate about the face of the first exterior shell.

2. The mechanical arm of claim 1, wherein the base extension can pivot in at least two directions from 0 degrees about the vertical to at least one of 22.5 degrees or 45 degrees.

3. The mechanical arm of claim 1, wherein the first exterior shell is not connected to rotate with the first interior member when the first interior member rotates.

4. The mechanical arm of claim 1, further comprising a base coupling to receive the first interior member of the base extension, and to move the first interior member about three degrees of freedom.

5. The mechanical arm of claim 4, wherein the base coupling corresponds to a gimbal.

6. The mechanical arm of claim 5, wherein the joint is a U-joint.

7. The mechanical arm of claim 1, wherein the face of the first exterior shell and the face of the second exterior shell are each asymmetrical about at least one axis.

8. The mechanical arm of claim 1, wherein the face of the first exterior shell and the face of the second exterior shell form a conical joint.

9. The mechanical arm of claim 1, wherein the arm extension includes an adapter interface at a distal end to receive an extension component.

10. The mechanical arm of claim 1, wherein the arm extension includes a replaceable extension component on a distal end.

11. A cooking apparatus comprising:

a controller;

a housing including a hot region;

a receptacle to receive food items for preparation over the hot region;

an arm assembly extending downward from the housing into the receptacle, the mechanical arm assembly including:

a base extension, including a first interior member and a first exterior shell;

at least one motor coupled to move the first interior member so that the first interior member has three degrees of freedom;

an arm extension extending from the base extension, the arm extension including a second interior member and a second exterior shell;

a joint to couple the first interior member to the second interior member, the joint including a first end to receive the first interior member and a second end to receive the second interior member;

wherein the base extension, the arm extension, and the joint combine to position a face of the first exterior shell against a face of the second exterior shell;

wherein the at least one motor operates to rotate the first interior member while the first interior member is received by the joint, causing (i) the second interior member to rotate, and the face of the second exterior shell to rotate about the face of the first exterior shell.

12. The cooking apparatus of claim 11, wherein the base extension can pivot in at least two directions from 0 degrees about the vertical to at least one of 22.5 degrees or 45 degrees.

13. The cooking apparatus of claim 11, wherein the first exterior shell is not connected to rotate with the first interior member when the first interior member rotates.

14. The cooking apparatus of claim 11, further comprising a base coupling to receive the first interior member of the base extension, and to move the first interior member about three degrees of freedom.

15. The cooking apparatus of claim 14, wherein the base coupling corresponds to a gimbal.

16. The cooking apparatus of claim 15, wherein the joint is a U-joint.

17. The cooking apparatus of claim 11, wherein the face of the first exterior shell and the face of the second exterior shell are each asymmetrical about at least one axis.

18. The cooking apparatus of claim 11, wherein the face of the first exterior shell and the face of the second exterior shell form a conical joint.

19. The cooking apparatus of claim 11, wherein the arm extension includes an adapter interface at a distal end to receive an extension component.

20. The cooking apparatus of claim 1, wherein the arm extension includes a replaceable extension component on a distal end.

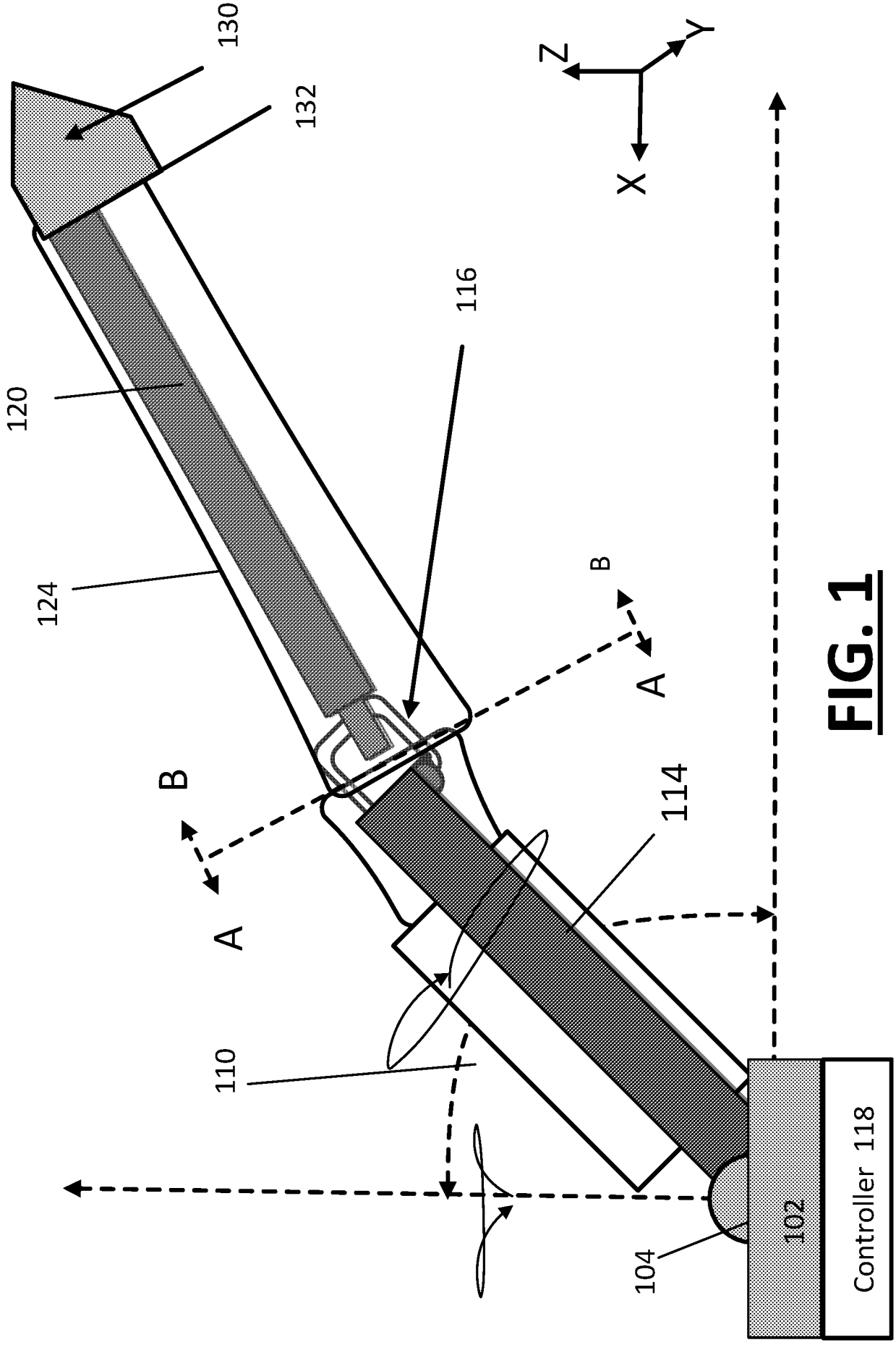

FIG. 1

202

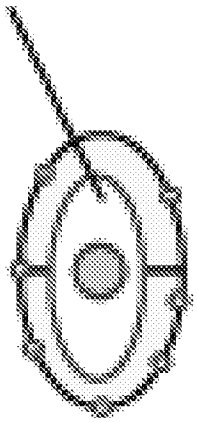

FIG. 2A

204

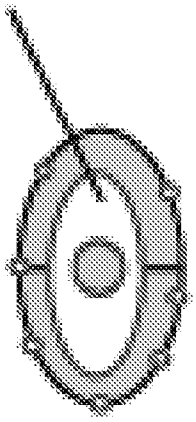

FIG. 2B

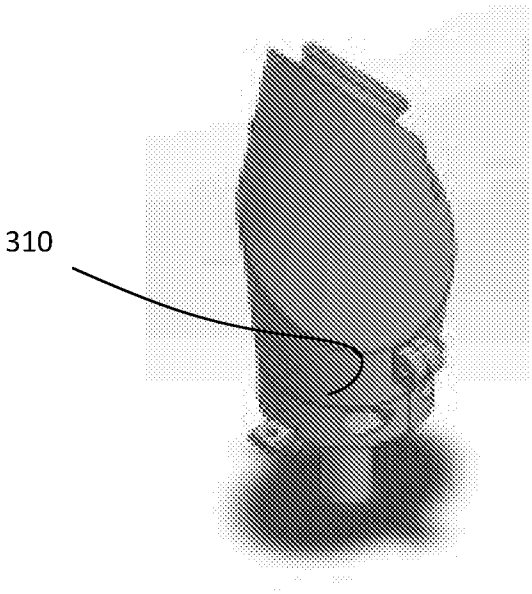

FIG. 3A

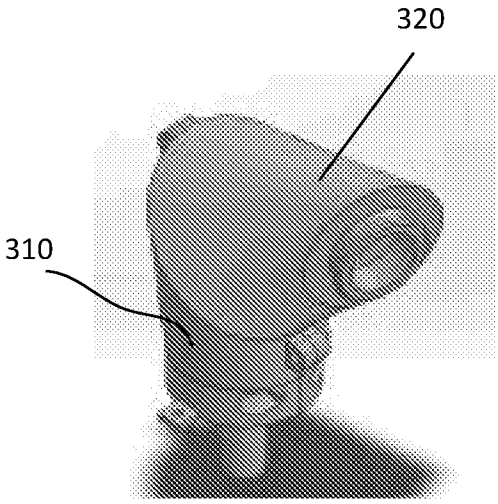

FIG. 3B

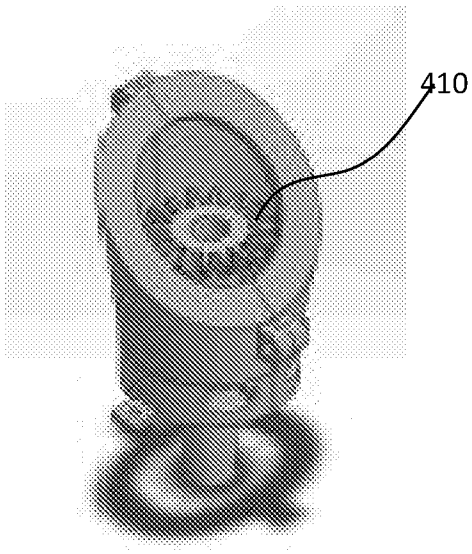

FIG. 4A

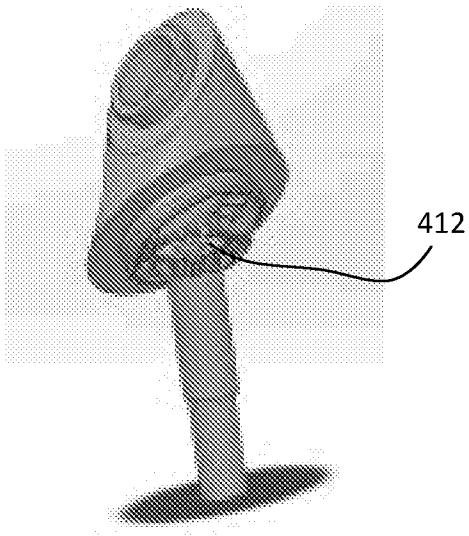

FIG. 4B

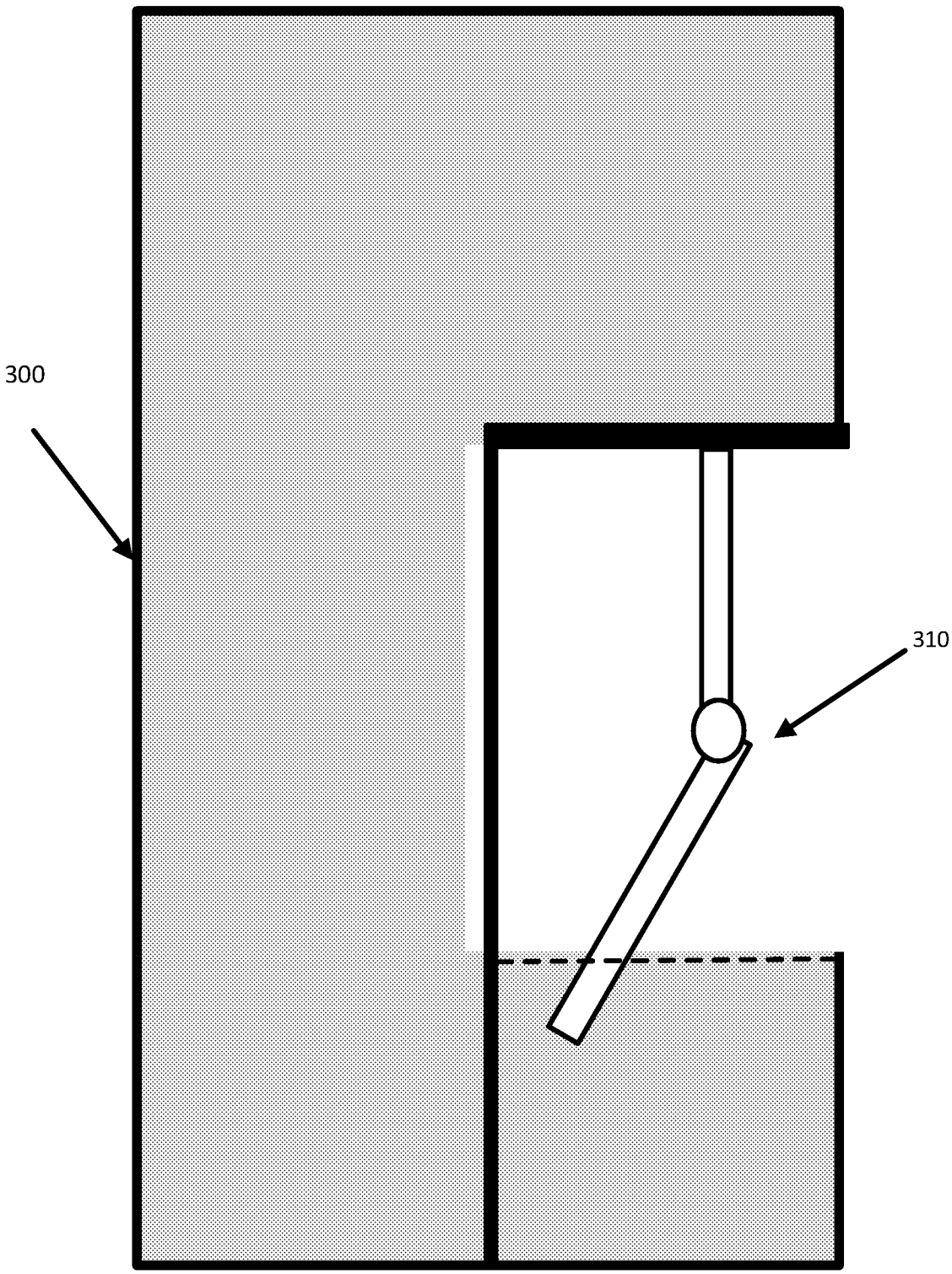

FIG. 5

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US 2016/023310

A. CLASSIFICATION OF SUBJECT MATTER

B25J 11/00 *(2006.01)*
B25J 13/00 *(2006.01)*
A47J 44/02 *(2006.01)*

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

B25J 13/00, 19/00, 11/00, A47J 44/00, 44/02

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)

PatSearch (RUPTO internal), USPTO, PAJ, Esp@cenet, Information Retrieval System of FIPS

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	CN 102501242 A (UNIV SOUTH CHINA TECH) 20.06.2012, abstract, fig. 1	1-20
Y	US 5386762 A (PHILLIP E GOKEY) 07.02.1995, fig. 1, column 10, lines 35-48	11-20
Y	WO 9217313 A2 (GEODETIC MACHINES LIMITED) 15.10.1992, abstract, fig. 8-12C	1-20
Y	EP 427358 B1 (ALLEN GEORGE S et al) 15.05.1995, claim 1	5, 6, 15, 16
A	EP 441397 A1 (HITACHI LTD) 14.08.1991	1-20

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

☐ See patent family annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
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