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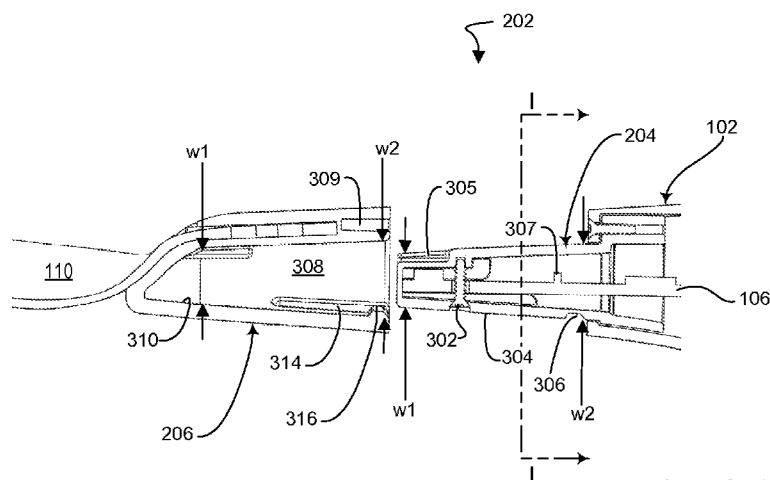


Fig. 3A

(57) Abstract: Embodiments are disclosed of an adapter for coupling an implement to a tremor cancellation platform. The adapter includes a first section attached to the tremor cancellation platform, the first section comprising an elongated tapered key having a base and a tip, the base having a greater transverse dimension than the tip and the base being attached to the tremor cancellation platform. The adapter also includes a second section coupled to the implement, the second section including a tapered cavity sized and shaped to receive the first section, and a latch to lock the second section onto the first section.



**ADAPTER TO ATTACH IMPLEMENTS TO AN ACTIVELY CONTROLLED
HUMAN TREMOR CANCELLATION PLATFORM**

CROSS-REFERENCE TO RELATED APPLICATIONS

5 [0001] This application claims priority under 35 U.S.C. § 119(e) to U.S. Provisional Application No. 61/982,240, filed 21 April 2014 and still pending.

TECHNICAL FIELD

10 [0002] The disclosed embodiments relate to a tremor cancellation platform and more particularly, but not exclusively, to a tremor cancellation platform including an adapter for attaching different implements to the tremor cancellation platform.

BACKGROUND

15 [0003] A significant percentage of the world's population suffers from neurological motion disorders. In the United States alone, up to ten million people suffer from Essential Tremor and 1 million suffer from Parkinson's disease. In many of these motion disorders, upper limb tremors can interfere with patients' daily activities such as eating, writing, etc. Medications are variably effective and often come with side effects. Surgical treatments are effective, but they can be costly and are typically reserved for much more severe cases. Improved
20 therapies, therefore, are currently needed.

 [0004] A handheld tremor cancellation platform has been developed that is noninvasive and actively cancels the transmission of an individual's tremor to an implement being held. The tremor cancellation platform senses the tremor direction and moves the held object in an opposite direction to stabilize it. Because the device compensates for the tremor but does not
25 act to suppress the tremor, it can use much smaller actuators, enabling an extremely lightweight and compact form factor.

 [0005] Practical attachment of implements improves operation and use of the tremor cancellation platform. Attachment of implements to the tremor cancellation platform must be intuitive, especially for someone with hand tremor, and it must facilitate the overall waterproofing of the device. The implement must also be securely held once attached to the tremor
30 cancellation platform. Traditional attachment techniques have drawbacks that do not satisfy the aforementioned requirements.

BRIEF DESCRIPTION OF THE DRAWINGS

[0006] Non-limiting and non-exhaustive embodiments of the invention are described with reference to the following figures, in which like reference numerals refer to like parts throughout the various views unless otherwise specified.

5 [0007] Fig. 1A is a cross-sectional drawing of an embodiment of a tremor cancellation platform.

[0008] Fig. 1B is a perspective view of an embodiment of a tremor cancellation platform.

10 [0009] Figs. 2A–2B are bottom and side views, respectively, of an embodiment of an adapter for attaching a user implement to a tremor cancellation platform.

[0010] Fig. 3A is a longitudinal cross-sectional view of an embodiment of an adapter for attaching a user implement to a tremor cancellation platform.

[0011] Fig. 3B is a transverse cross-sectional drawing of the embodiment of an adapter shown in Fig. 3A, taken substantially along section line I–I.

15 [0012] Fig. 3C is a transverse cross-sectional drawing of the embodiment of an adapter shown in Fig. 3A showing an implement attached to the tremor cancellation platform using the embodiment of an adapter.

[0013] Fig. 4 is a circuit diagram of an embodiment of a contactless switch that can be used in an embodiment of the adapter.

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DETAILED DESCRIPTION OF THE ILLUSTRATED EMBODIMENTS

[0014] Embodiments are described of an apparatus, system and method for an adapter for attaching different implements to a tremor cancellation platform. Specific details are described to provide a thorough understanding of the embodiments, but one skilled in the relevant
25 art will recognize that the invention can be practiced without one or more of the described details, or with other methods, components, materials, etc. In some instances, well-known structures, materials, or operations are not shown or described in detail but are nonetheless encompassed within the scope of the invention.

[0015] Reference throughout this specification to “one embodiment” or “an embodiment” means that a described feature, structure, or characteristic can be included in at least
30 one described embodiment, so that appearances of “in one embodiment” or “in an embodiment” do not necessarily all refer to the same embodiment. Furthermore, the particular features, structures, or characteristics may be combined in any suitable manner in one or more embodiments.

[0016] Figs. 1A–1B together illustrate a handheld tool 100 that measures and compensates for unintentional muscle movements. Fig. 1A is a cross-sectional view, Fig. 1B a perspective view. Handheld tool 100 can detect and compensate for unintentional muscle movement (tremors). Accordingly, the illustrated embodiment includes subsystems to detect and compensate for tremors. These subsystems can have distinct components, or share some components such as power systems, memory, a controller, and one or more sensors. In some embodiments, one or more components of the subsystem for detecting and compensating for tremors can be omitted.

[0017] Handheld tool 100 includes a tremor cancellation platform 102, which functions as a handle for holding handheld tool 100. Handheld tool 100 also includes an attachment arm 106 coupled to tremor cancellation platform 102. Attachment arm 106 is configured to accept an implement 110 (e.g., a spoon in the illustrated embodiment) on its end, thus coupling the implement to tremor cancellation platform 102.

[0018] The illustrated embodiment of tremor cancellation platform 102 includes a subsystem 104 for detecting and compensating for tremors of implement 110. In the illustrated embodiment, subsystem 104 includes distributed motion sensors 120 to measure movement of tremor cancellation platform 102 and implement 110. Subsystem 104 further includes a portable power source 112, a motion-generating mechanism 114, a controller 116, a control system 118, and at least one distributed motion sensor 120 for measuring relative motion of attachment arm 106 relative to housing 102. In other embodiments, one or more of the components of subsystem 104 for compensating tremor motions can be omitted (e.g., inertial sensor 108, motion-generating mechanism 114, etc.) while still implementing the tremor detection and compensation functionality.

[0019] In one embodiment, attachment arm 106 is integrated with a specific type of implement 110 (spoon illustrated). In other embodiments, attachment arm 106 can receive a variety of different implements 110 in a variety of ways including but not limited to a friction, snap, or other form of locking mechanism (see, e.g., Figs. 3A–3C). Portable power source 112 can use a variety of options including a rechargeable battery, a solar panel, etc.

[0020] The at least one distributed motion sensor 120 detect unintentional muscle movements and measure signals related to these unintentional muscle movements that are created when a user adversely affects motion of implement 110. These sensors also detect the motion of the stabilized output relative to the housing 102. Control system 118 sends voltage commands in response to the signals to the motion-generating mechanism 114 through the controller 116 to cancel the user's tremors or unintentional muscle movements. This cancellation

maintains and stabilizes a position of the implement 110, keeping it centered relative to the housing 102.

[0021] Different embodiments of tremor cancellation platform 102 can use various implementations of controller 116, at least one distributed motion sensor 120, and control system 118, and still be within the scope of the present disclosure. In one embodiment, controller 116 comprises an electrical system capable of producing an electrical response from sensor inputs such as a programmable microcontroller a field-programmable gate array (FPGA), an application specific integrated circuit ("ASIC"), or otherwise. In one embodiment, controller 116 comprises an 8-bit ATMEGA8A programmable microcontroller manufactured by Atmel due to its overall low cost, low power consumption and ability to be used in high-volume applications.

[0022] In one embodiment, the at least one distributed motion sensor 120 is a contactless position sensor including but not limited to a hall-effect magnetic sensor. In one embodiment, the control system 118 is a closed-loop control system. The closed-loop control system senses motion and acceleration at various points along handheld tool 100 and feeds detailed information into a control algorithm that moves motion-generating mechanism 114 appropriately to cancel the net effect of a user's unintentional muscle movements and thus stabilize the position of implement 110.

[0023] Although in the illustrated embodiment implement 110 is a spoon, in other embodiments it can be a different implement such as a manufacturing tool, a surgical tool, a kitchen utensil (e.g., fork, knife, spoon), a sporting tool, a yard tool, a grooming tool (e.g., comb, nail clippers, tweezers, make-up applicator, etc.), a dental hygiene tool (e.g., toothbrush, flossing tool, etc.), or a pen or pencil. Thus, handheld tool 100 can be useful not only for improving the quality of life of individuals suffering from neurological motion disorders, but also for a variety of applications where physiological tremor is an issue, including but not limited to manufacturing, surgical and public safety applications.

[0024] In the illustrated embodiment, the at least one distributed motion sensor 120 is located within the tremor cancellation platform 102. The at least one distributed motion sensor 120 measures the relative motion of attachment arm 106 relative to the housing 102, wherein implement 110 is kept at a center position relative to housing 102. In one embodiment, the at least one distributed motion sensor 120 is at least one contactless hall-effect position sensor that provides angular feedback for control system 118 and relies on a changing magnetic field that is dependent on the actuation angle.

[0025] The changing magnetic field is detected by a strategically placed integrated

circuit (IC) located within the at least one distributed motion sensor 120, whose analog output is read by controller 116, providing a completely non-contact angular detection that is capable of withstanding a large number of cycles. The at least one distributed motion sensor 120, with its contactless sensing methods, provides improved reliability over conventional direct-contact sensing methods such as potentiometers that wear over time.

[0026] In one embodiment, handheld tool 100 uses a combination of coreless micro-motors and miniature gear-reduction systems coupled to the coreless micro-motors using a coupling mechanism to implement motion-generating mechanism 114. Significant force of up to 10 Newtons (N) can also be produced with these coreless micro-motors at the required tremor frequency of 0-5 hertz (Hz) through the use of a low-cost miniature gear-reduction system, with a total weight of only 6.5 grams (g). Furthermore, the power drawn from this technology is low, estimated at 0.5 watts (W).

[0027] Figs. 2A–2B illustrate an embodiment of an adapter 202 for attaching an implement 110 to a tremor cancellation platform 102. Fig. 2A is a bottom view, Fig. 2B a side view. Adapter 202 enables connection many different implements 110 to the tremor cancellation platform 102 and ensures correct orientation of implement 110 and ease of insertion when the user is experiencing tremor.

[0028] Adapter 202 includes two main parts: a first section first adapter section 204 coupled to tremor cancellation platform 102, and a second adapter section 206 coupled to implement 110. An implement is a tool, utensil, or other piece of equipment used for a particular purpose. In the illustrated embodiment implement 110 is a spoon, but in other embodiments implement 110 can be any of various tools, for instance a manufacturing tool, a surgical tool, a kitchen utensil (e.g., fork, knife, spoon), a sporting tool, a yard tool, a grooming tool (e.g., comb, nail clippers, tweezers, make-up applicator, etc.), a dental hygiene tool (e.g., toothbrush, flossing tool, etc.), or a pen, pencil or paintbrush.

[0029] First adapter section 204 is a tapered key designed to fit within second adapter section 206: the tapered key that forms first adapter section 204 drafts to a narrower cross section as it moves away from the tremor cancellation platform. The taper allows clearance between the opening of the second adapter section and the tip of the first adapter section, making it easy to insert for a user with hand tremors. And first adapter section 204 has a keyed shape that rejects second adapter portion 206 if it is not inserted in the correct orientation. Visual cues can also be included as part of the attachment to facilitate correct insertion orientation.

[0030] Adapter 102 also provides a way to turn on the tremor cancellation platform's power without the need for a user to interact with a physical button or switch. It includes a con-

tactless power switch that automatically activates the stabilization system when first adapter section 204 is secured within second adapter section 206. This enables intuitive use as well as simplicity, water-proofing, and long-term reliability.

[0031] Figs. 3A–3C illustrate details of an embodiment of adapter 202. Fig. 3A is a longitudinal (i.e., side) cross-section, while Figs. 3B–3C are transverse cross sections. Fig. 3A illustrates the details of first adapter section 204 and second adapter section 206. In the illustrated embodiment first adapter section 204 is a tapered key having a hollow interior to receive attachment arm 106. Tapered key 204 is attached to attachment arm 106 by screw 302. First adapter section 204 has a base with transverse dimension w_2 positioned closest to tremor cancellation platform 102 and has a tip of transverse dimension w_1 positioned furthest from platform 102. Tapered key 204 is tapered so that its tip is narrower than its base—that is, it has a taper ratio w_1/w_2 less than 1. In different embodiments taper ratio w_1/w_2 can be between zero (i.e., a sharp tip) and just under 1.

[0032] Outer surface 304 of tapered key 204 includes a slot 305 at or near its tip to receive a corresponding element from second adapter section 204. Outer surface 304 also includes one or more slots, notches, or both 306 to receive a latch 314/316 from the second adapter section, thereby keeping the second adapter section firmly attached to the first. Also positioned inside tapered key 204 is a contactless switch 307, as well as associated circuitry that can be on a circuit board in the hollow interior of the tapered key.

[0033] Second adapter section 206 includes an open-ended cavity 308 sized and shaped to receive first adapter section 206. Cavity 308 is also tapered, with transverse dimension w_2 at its open end and transverse dimension w_1 at its closed end, so that it has substantially the same taper ratio as tapered key 204. Outer surface 304 of tapered key 204 corresponds substantially in size and shape to inner surface 310 of open-ended cavity 308 so that, when tapered key 204 is inserted into cavity 308 outer surface 304 is substantially in contact with inner surface 310. This results in a tight waterproof fit.

[0034] At least one compliant latch 314 can be positioned inside cavity 308 to engage tapered key 204, and can include a tab 316 that will engage detent or slot 306 in tapered key 204 to keep the second adapter section firmly attached to the first adapter section. Once the second adapter section 206 is fitted to tapered key 204, it is pressed toward tremor cancellation platform 102 until the compliant latch locks the implement to the tremor cancellation platform. This latch can be used to produce sufficient friction to prevent unintentional separation of the attachment from the attachment arm. A compliant latch can also be fabricated in the second adapter section so that a tab 316 can lock into a detent or slot 306 in outer surface 304 of the

tapered key. Compliant latch 314 and tab 316 be constructed from the plastic itself. In other embodiments a ball detent mechanism or some other mechanism can be used instead of, or in addition to, compliant latch 314 and tab 316.

[0035] Second adapter section 206 can also include a permanently embedded magnet 309. When tapered key 204 is fully inserted into second adapter section 206, embedded magnet 309 comes close enough to contactless switch 307 to activate it (i.e., close it), thus automatically activating tremor cancellation platform 102. This allows a user with tremors to avoid the extra step of manually activating a switch. In the illustrated embodiment a contactless Reed switch is used in tapered key 204 to sense when embedded magnet 309 comes near and to then activate power to the tremor cancellation platform. Magnet 309 activates the contactless switch only when the second adapter section 206 is fully secured on tapered key 204. Other magnetic sensing devices can be employed in the place of the Reed switch including, for instance, Hall-effect sensors.

[0036] Figs. 3B illustrates the cross-sectional shape of tapered key 204. The cross-sectional shape of the tapered key is a non-circular, non-symmetric shape that can constrain rotation of the attachment relative to the attachment arm. This cross-sectional shape also allows second adapter section 206 to fit on tapered key 204 in only one orientation, so that implement 110 can only be attached in the correct orientation—in the illustrated embodiment, the spoon can only connect to tremor cancellation platform 102 with the bowl of the spoon facing up. Visual markings can also be placed on the surface 304 of the tapered key and on the outside of second adapter section 206 to assist the user in attaching the implement in the correct orientation.

[0037] Outer surface 304 of tapered key 204 has two parts: a substantially flat part 320 and a curved part 322 that merges smoothly with substantially flat part 320. The cross-sectional shape of tapered key 214 is non-circular and non-symmetric, meaning that it has no more than one plane of symmetry; in the illustrated embodiment, for instance, the cross-section of outer surface 304 is symmetrical about line 326, but not symmetric about line 324. This is referred to is a keyed cross-section, hence the description of first adapter section 204 as a tapered key. The keyed cross-section ensures that first adapter section 204 can only be inserted into cavity 308 in one orientation; that way implement 110 can only be installed on tremor cancellation platform 102 in the correct orientation. In other embodiments, first adapter section 204 can of course have different cross-sectional shapes than shown. In other embodiments, for instance, the cross-sectional shape of first adapter section 204, and the corresponding interior shape of open ended cavity 308, can be designed to automatically rotate second adapter section

206 to the correct orientation no matter what the orientation is when insertion of first adapter section 204 into cavity 308 begins.

[0038] Fig. 3C illustrates a cross-section of first adapter section 204 inserted into second adapter section 206. First adapter section 204 is positioned within cavity 308 and substantially fills it, so that all of outer surface 304 of first adapter section 204 is substantially in contact with inner surface 310 of cavity 308. This ensures a tight and somewhat waterproof substantially waterproof fit. At least one conforming latch 314 and tab 316 engage a corresponding notch or detent 306 in outer surface 304 to keep the first adapter section securely fastened to the second.

[0039] Fig. 4 illustrates an embodiment of a contactless switch circuit 400 that can be used with embodiments of adapter 202 for automatic activation of the tremor cancellation platform. Circuit 400 includes a contactless switch 402. In the illustrated embodiment contactless switch 402 is a reed switch, but in other embodiments it can be another type of contactless switch, for instance a Hall Effect switch. Switch 402 is electrically coupled to power supply 410 and platform 102 via resistor 408 and transistor 406 as shown. In the illustrated embodiment transistor 406 is a high-side transistor (such as a MOSFET), but a low-side transistor can be employed with equal efficacy in other embodiments. When magnet 404 is brought near contactless switch 402 it activates the switch. Once the contactless switch is closed by a nearby magnetic field transistor 406 is activated, allowing current to flow from power supply 410 into tremor cancellation platform 102. If no magnetic field is present the transistor allows no current to flow, thus saving power when the device is not being used. The circuit provided is thus one example of a power-conserving strategy, but in other embodiments other configurations that allow power-saving can be used.

[0040] The above description of illustrated embodiments of the invention, including what is described in the abstract, is not intended to be exhaustive or to limit the invention to the precise forms disclosed. While specific embodiments of, and examples for, the invention are described herein for illustrative purposes, various equivalent modifications are possible within the scope of the invention, as those skilled in the relevant art will recognize. These modifications can be made to the invention in light of the above detailed description.

[0041] The terms used in the following claims should not be construed to limit the invention to the specific embodiments disclosed in the specification and the claims. Rather, the scope of the invention is to be determined entirely by the following claims, which must be construed using established doctrines of claim interpretation.

CLAIMS

1. An adapter for coupling an implement to a tremor cancellation platform, the adapter comprising:
 - a first section attached to the tremor cancellation platform, the first section comprising an elongated tapered key having a base and a tip, the base having a greater transverse dimension than the tip and the base being attached to the tremor cancellation platform;
 - a second section coupled to the implement, the second section including a tapered cavity sized and shaped to receive the first section; and
 - a latch to lock the second section onto the first section.
2. The adapter of claim 1 wherein the cross-sectional shape of the elongated key is non-symmetric to prevent the implement from being attached to the tremor cancellation platform in the wrong orientation.
3. The adapter of claim 2 wherein the cross-sectional shape of the elongated tapered key includes a substantially flat portion smoothly connected to a curved portion.
4. The adapter of claim 1, further comprising a contactless switch positioned in the first section to automatically activate the tremor cancellation platform when the first section is inserted in the second section.
5. The adapter of claim 4 wherein the contactless switch is magnetically activated and wherein the second section includes an embedded magnet positioned to activate the contactless switch when the first section is inserted in the second section.
6. The adapter of claim 1 wherein the latch comprises a spring-loaded ball in the tapered cavity of the second section that engages a corresponding notch in the first section.
7. The adapter of claim 1 wherein the latch comprises a spring-loaded tab in the tapered cavity of the second section that engages a corresponding notch in the first section.
8. A tremor cancellation system comprising:
 - a tremor cancellation platform including a first adapter section, the first adapter section comprising an elongated tapered key having a base and a tip, the base having a greater transverse dimension than the tip and the base being attached to the tremor cancellation platform; and
 - an implement including a second adapter section, the second adapter section including a tapered cavity sized and shaped to receive the first adapter section and including a latch to lock the second adapter section onto the first adapter section so that the implement can be securely attached to the tremor cancellation platform.

9. The system of claim 9 wherein the cross-sectional shape of the elongated tapered key is non-symmetric to prevent the implement from being attached to the tremor cancellation platform in the wrong orientation.
10. The system of claim 9 wherein the cross-sectional shape of the elongated tapered key includes a substantially flat portion smoothly connected to a curved portion.
11. The system of claim 8, further comprising a contactless switch positioned in the first adapter section to automatically activate the tremor cancellation platform when the first adapter section is inserted in the second adapter section.
12. The system of claim 11 wherein the contactless switch is magnetically activated and wherein the second section includes an embedded magnet positioned to activate the contactless switch when the first section is inserted in the second section.
13. The system of claim 8 wherein the latch comprises a spring-loaded tab in the tapered cavity of the second adapter section that engages a corresponding notch in the first adapter section or a spring-loaded ball in the tapered cavity of the second adapter section that engages a corresponding notch in the first adapter section.
14. A tremor cancellation system comprising:
 - a tremor cancellation platform;
 - a first adapter section coupled to the tremor cancellation platform, the first adapter section comprising an elongated tapered key having a base, a tip, and a notch for receiving a latch, the base having a greater transverse dimension than the tip and the base being attached to the tremor cancellation platform.
15. The system of claim 14, further comprising:
 - a user implement;
 - a second adapter section coupled to the user implement, the second adapter section including a tapered cavity sized and shaped to receive the first adapter section and a latch that can mesh with the notch of the first adapter section to lock the second adapter section onto the first section so that the user implement is secured to the tremor cancellation platform.
16. The system of claim 15 wherein the cross-sectional shape of the elongated tapered key is non-symmetric to prevent the implement from being attached to the tremor cancellation platform in the wrong orientation.
17. The system of claim 16 wherein the cross-sectional shape of the elongated tapered key includes a substantially flat portion smoothly connected to a curved portion.

18. The system of claim 15, further comprising a contactless switch positioned in the first adapter section to automatically activate the tremor cancellation platform when the first adapter section is inserted in the second adapter section.
19. The system of claim 18 wherein the contactless switch is magnetically activated and wherein the second section includes an embedded magnet positioned to activate the contactless switch when the first section is inserted in the second section.

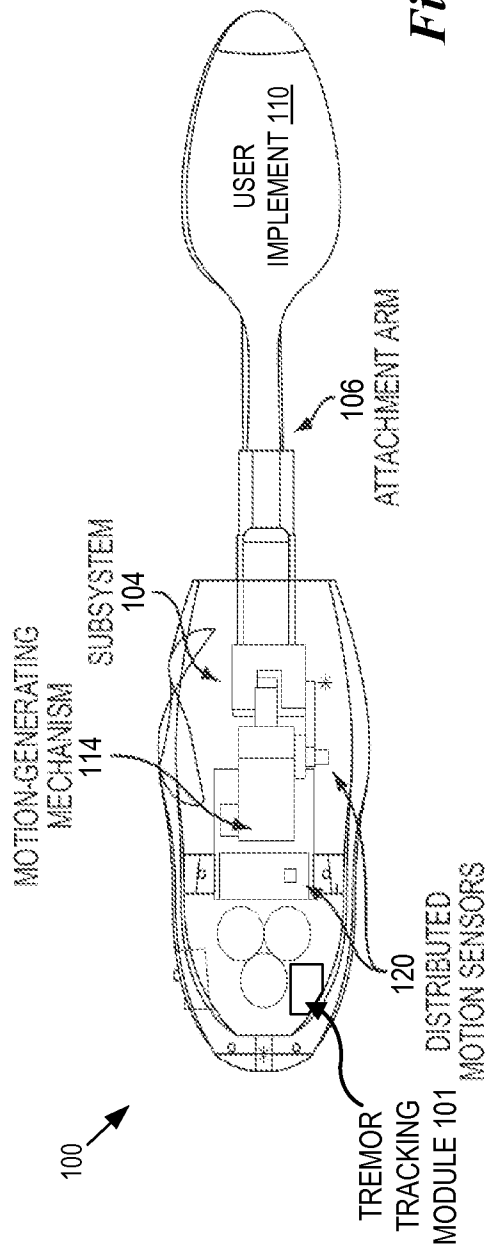


Fig. 1A

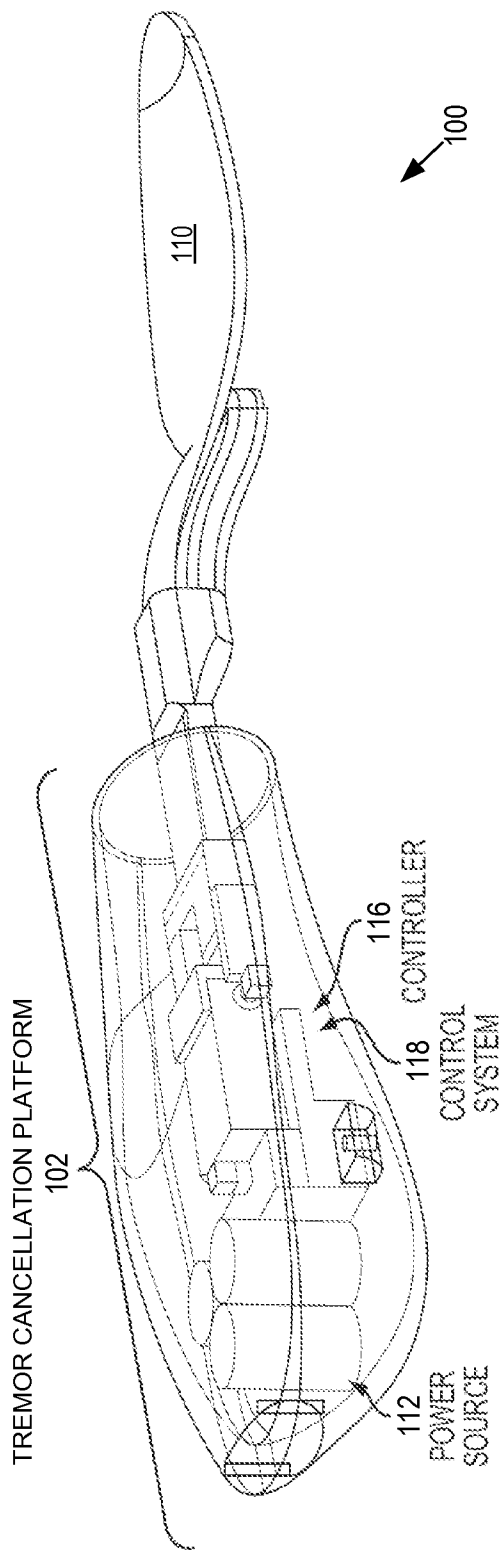


Fig. 1B

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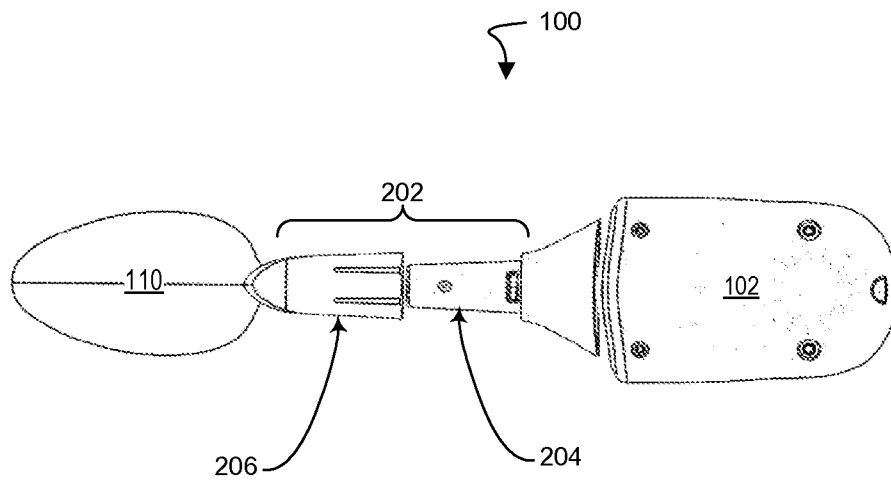


Fig. 2A

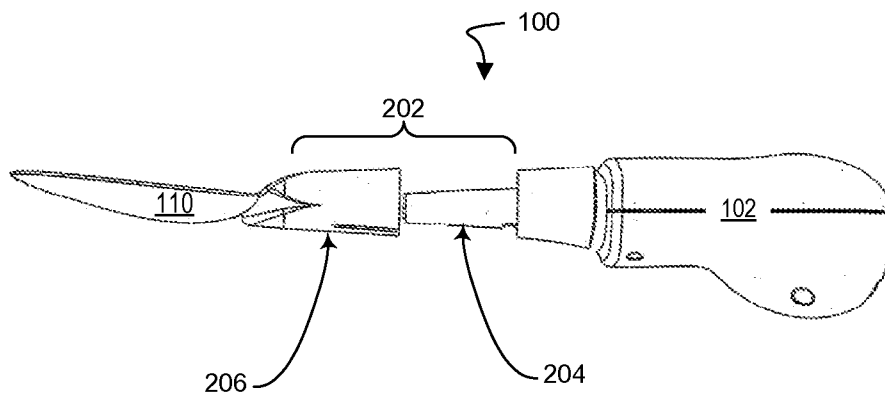


Fig. 2B

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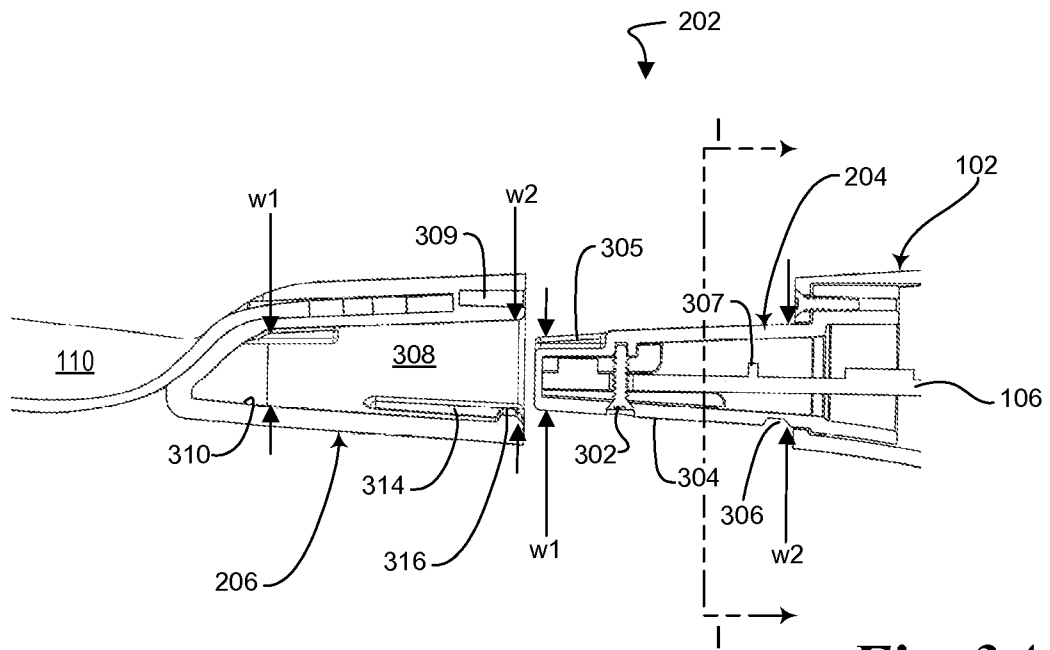
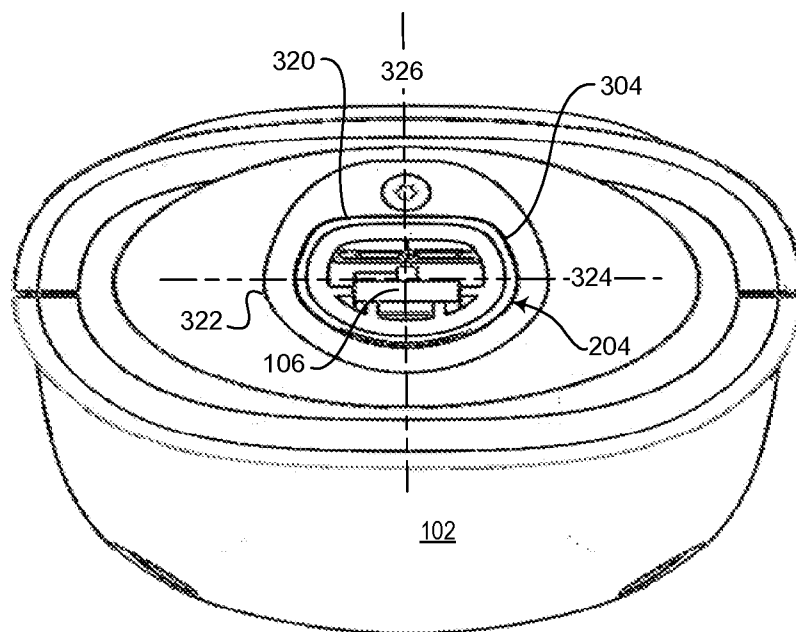


Fig. 3A



SECTION I-I

Fig. 3B

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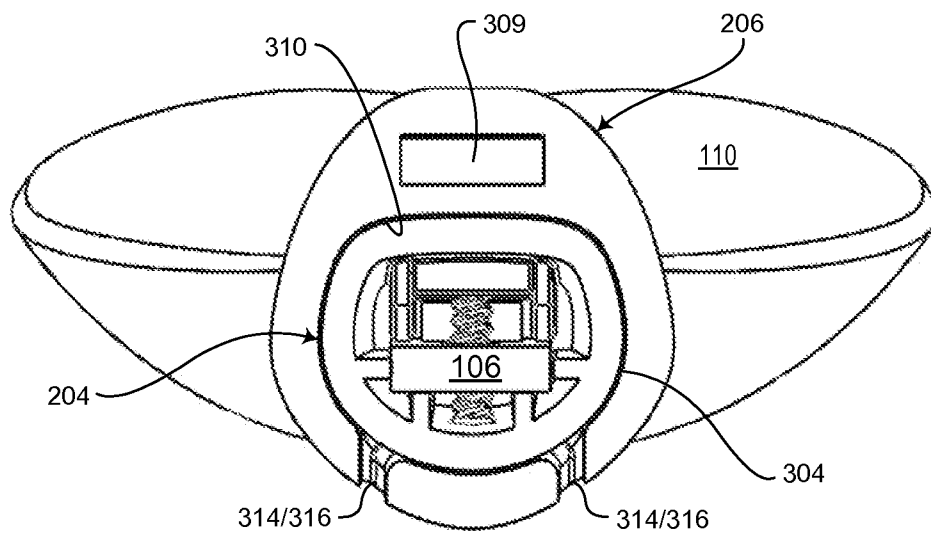
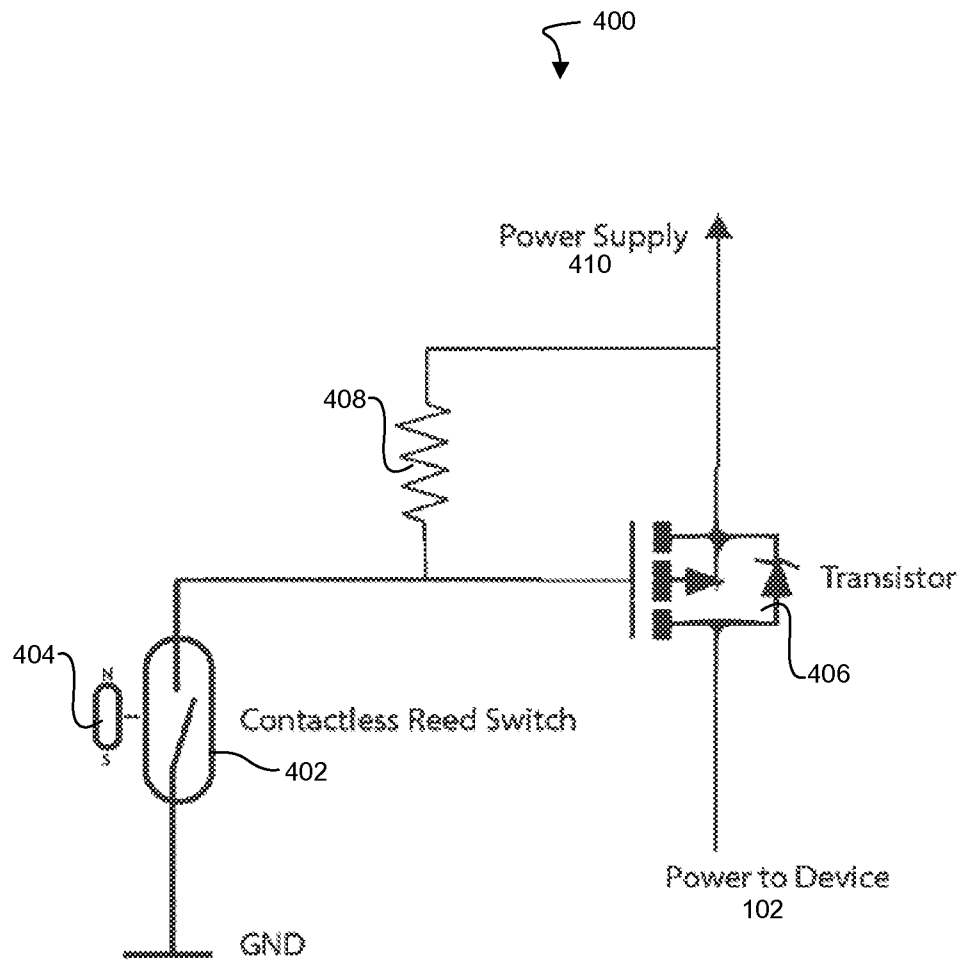


Fig. 3C

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**Fig. 4**

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2015/025781**A. CLASSIFICATION OF SUBJECT MATTER****A61B 19/00(2006.01)i**

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

B. FIELDS SEARCHEDMinimum documentation searched (classification system followed by classification symbols)
A61B 19/00; B25B 23/00; B25B 13/00; A61B 5/117; A61B 17/00; G08C 19/12; A61B 5/103Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Korean utility models and applications for utility models
Japanese utility models and applications for utility modelsElectronic data base consulted during the international search (name of data base and, where practicable, search terms used)
eKOMPASS(KIPO internal) & Keywords: tremor, cancellation, adapter, tip, cavity, latch, tapered, handheld, coupling, implement**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 8308664 B2 (PATHAK et al.) 13 November 2012 See column 3, lines 20-34; column 3, line 37-column 4, line 64; claims 14-21; and figures 1, 5A, 5B.	1-19
Y	US 2013-0118320 A1 (RICHARDSON, MICHAEL D.) 16 May 2013 See paragraphs [0048]-[0061]; claims 1-20; and figures 1-9.	1-19
A	US 2001-0012932 A1 (PEER, FERDINAND) 09 August 2001 See paragraphs [0001]-[0029]; claims 1-15; and figures 1, 2.	1-19
A	US 6695794 B2 (KAISER et al.) 24 February 2004 See column 1, line 50-column 8, line 38; claims 1-27; and figures 1-15.	1-19
A	US 2012-0249310 A1 (HOTALING, WILLIAM JAY) 04 October 2012 See paragraphs [0020]-[0055]; claims 1-20; and figures 1-6.	1-19

☐ Further documents are listed in the continuation of Box C.☒ See patent family annex.

* Special categories of cited documents:

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"&" document member of the same patent family

Date of the actual completion of the international search

26 June 2015 (26.06.2015)

Date of mailing of the international search report

01 July 2015 (01.07.2015)

Name and mailing address of the ISA/KR

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Information on patent family members

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