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(12) **United States Patent**
Ayer et al.

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(45) **Date of Patent: Aug. 12, 2025**

(54) **SYSTEM AND METHOD FOR INTEGRATED SURGICAL GUIDE-HUB AND DRILL WITH GUIDED DRILLING AND PLUNGE PROTECTION**

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

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(22) Filed: **May 15, 2023**

(65) **Prior Publication Data**

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Related U.S. Application Data

(60) Division of application No. 17/061,040, filed on Oct. 1, 2020, now Pat. No. 11,684,376, which is a
(Continued)

(51) **Int. Cl.**
A61B 17/16 (2006.01)
A61B 17/00 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC ***A61B 17/1695*** (2013.01); ***A61B 17/1628*** (2013.01); ***A61B 17/1739*** (2013.01);
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(58) **Field of Classification Search**
CPC . A61B 17/1695; A61B 90/03; A61B 17/1628; A61B 17/1739; A61B 2090/033; A61B 2017/00292
See application file for complete search history.

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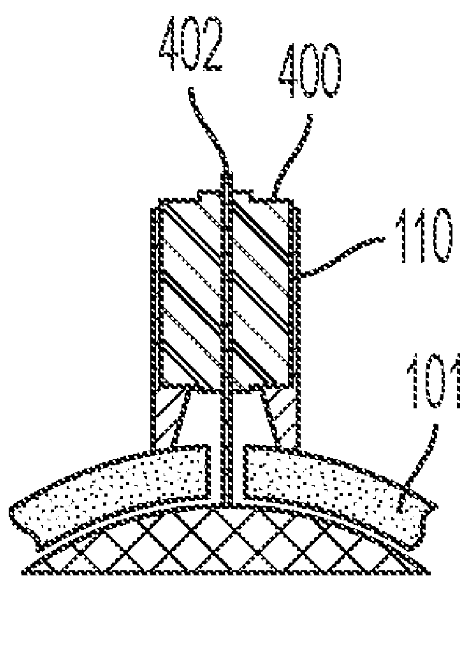
(74) *Attorney, Agent, or Firm* — Slater Matsil, LLP

(57) **ABSTRACT**

A method of using a medical tool comprising a cranial access drill includes placing a guide-hub against a cranial drilling surface, guiding a drill bit into the guide-hub along an axial direction of the guide-hub, drilling the cranial drilling surface in the axial direction with the drill bit using a motor, detecting, using a controller, an electrical parametric change at the drill bit that corresponds to puncturing the cranial drilling surface, and deactivating, using the controller, the motor in response to detecting the electrical parametric change.

20 Claims, 16 Drawing Sheets



Related U.S. Application Data

continuation of application No. PCT/US2019/063820, filed on Nov. 28, 2019.

(60) Provisional application No. 62/773,036, filed on Nov. 29, 2018.

(51) **Int. Cl.**
A61B 17/17 (2006.01)
A61B 90/00 (2016.01)

(52) **U.S. Cl.**
CPC ***A61B 90/03*** (2016.02); *A61B 2017/00292* (2013.01); *A61B 2090/033* (2016.02)

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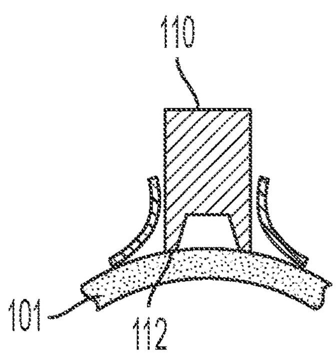


FIG. 1A

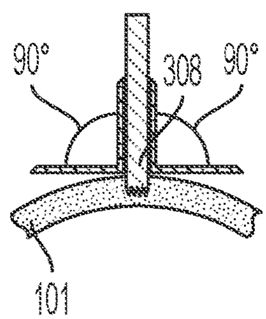


FIG. 1B

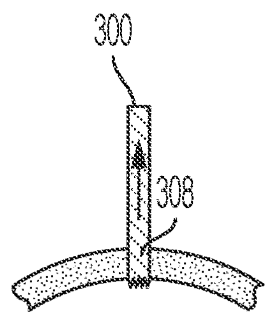


FIG. 1C

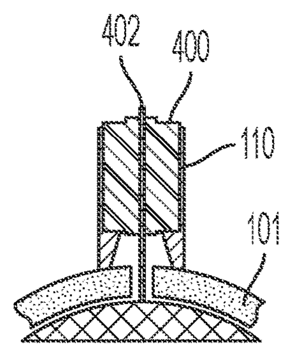


FIG. 1D

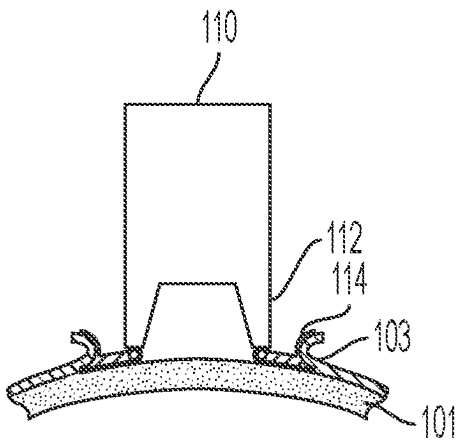
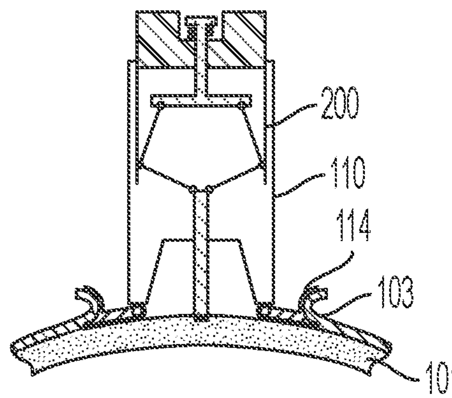


FIG. 2A



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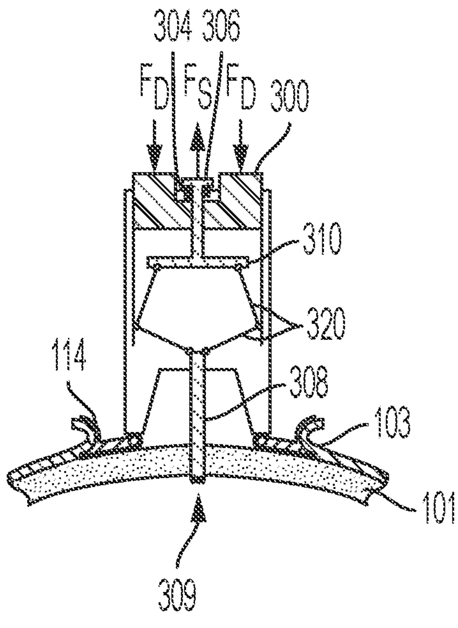

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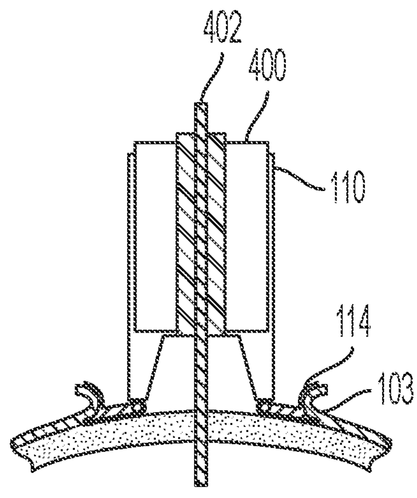

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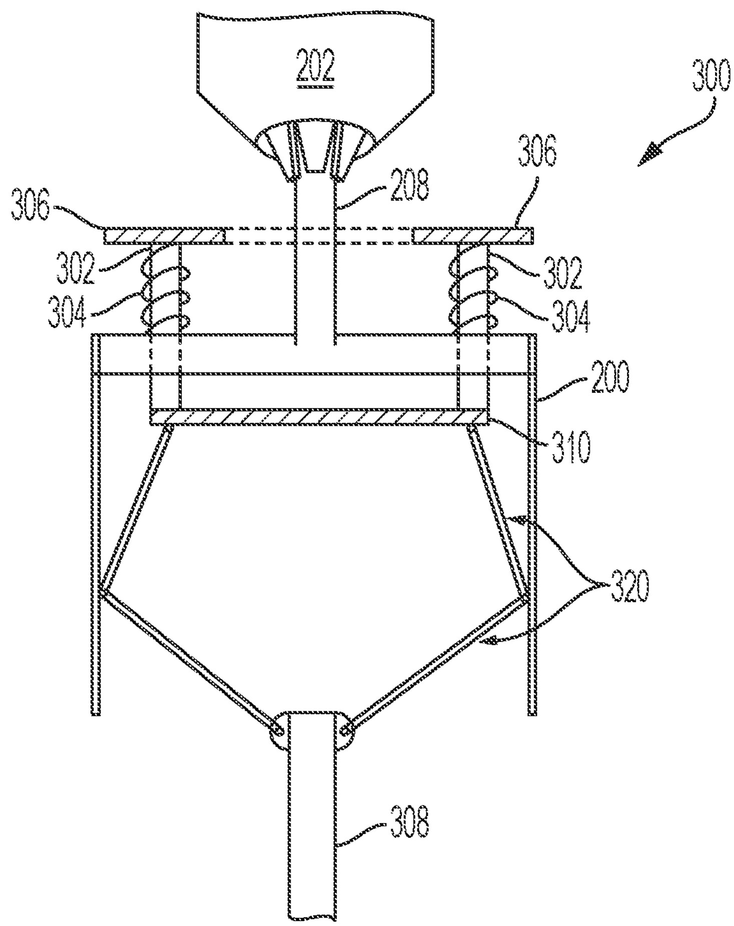

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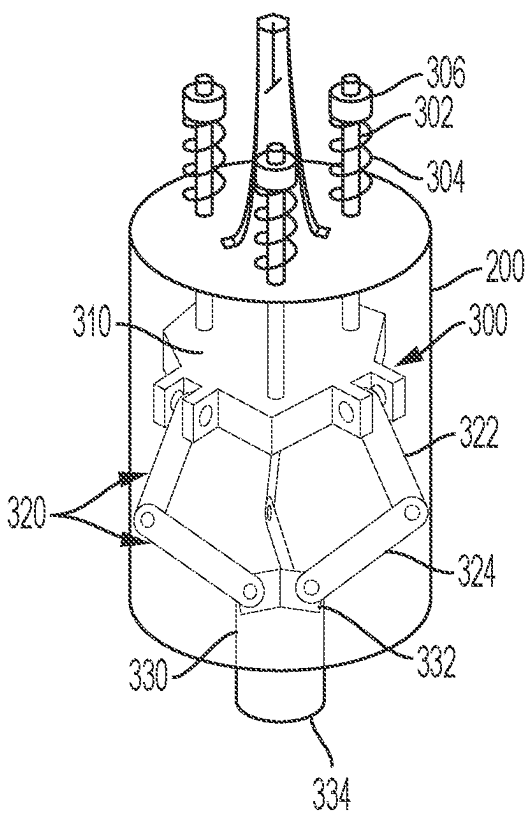


FIG. 4A

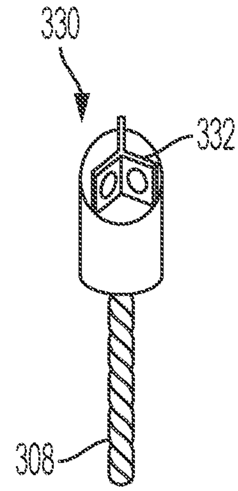
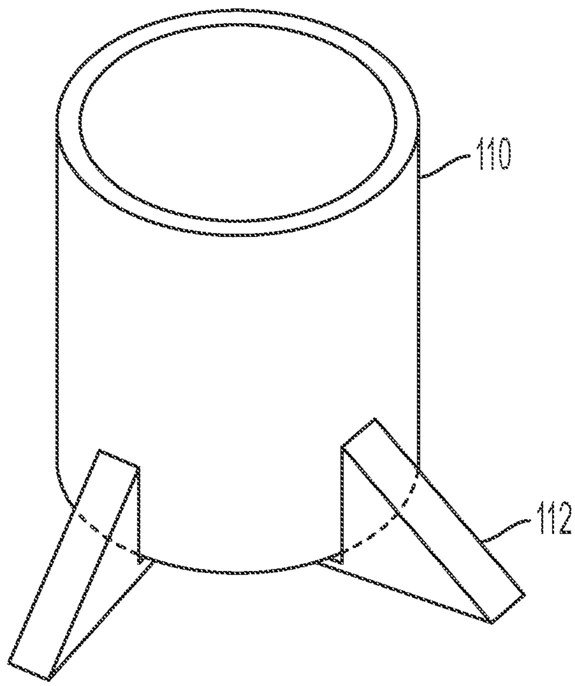


FIG. 4B



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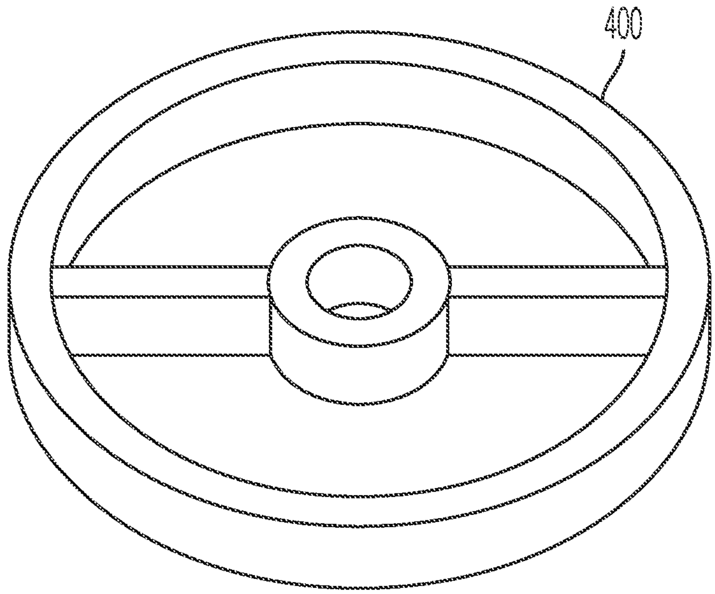


FIG. 6

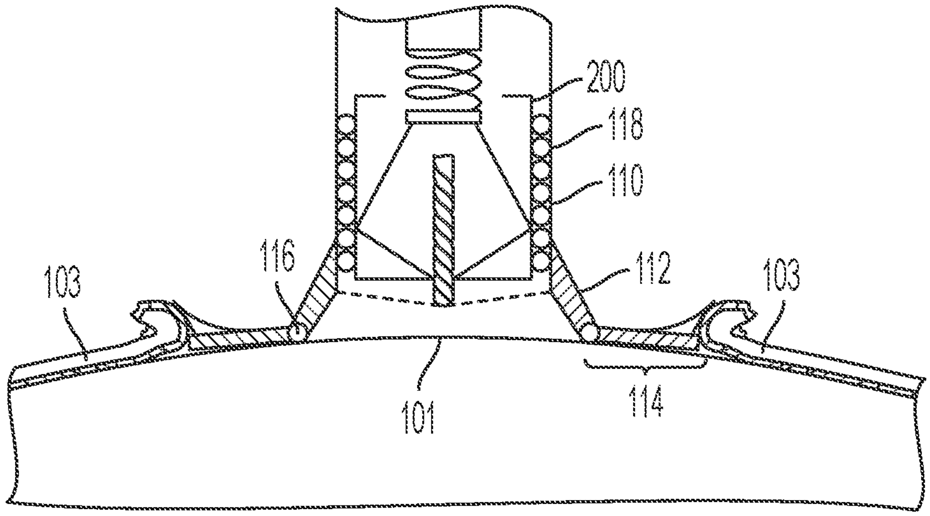


FIG. 7A

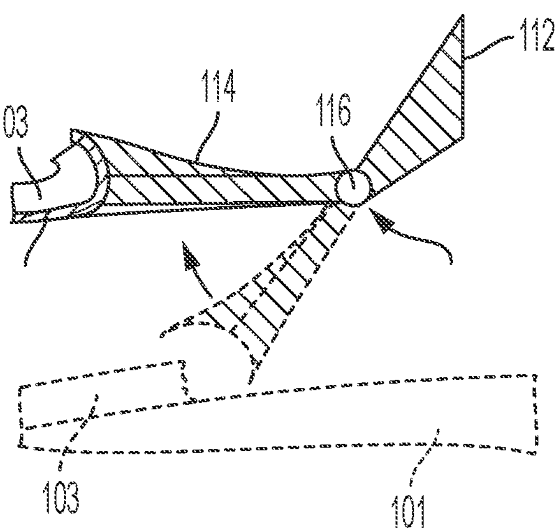


FIG. 7B

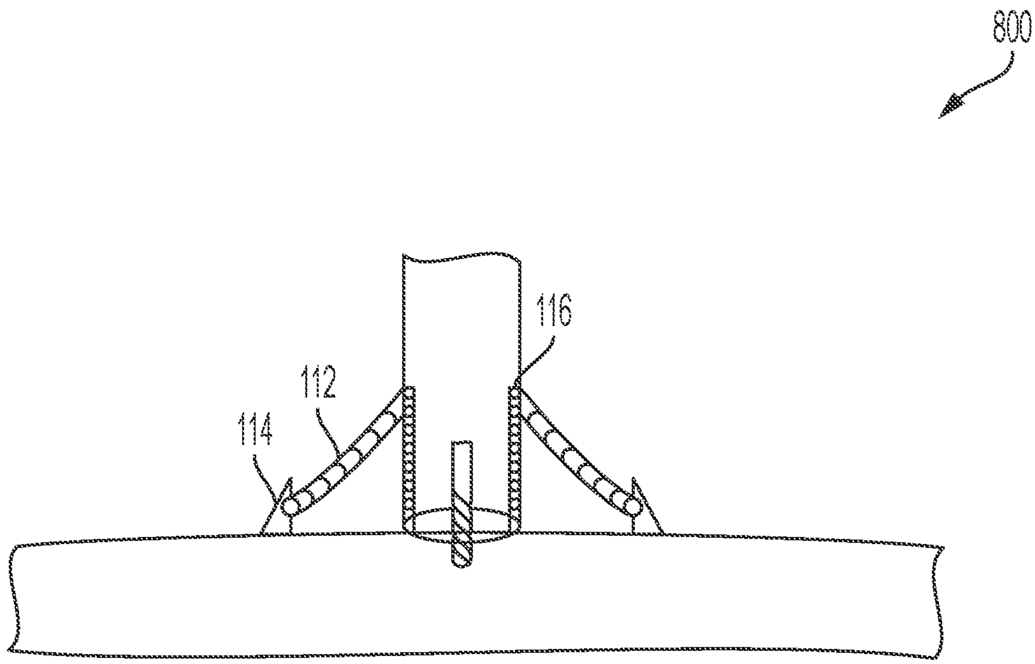
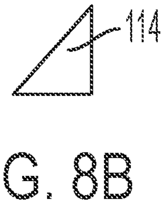


FIG. 8A



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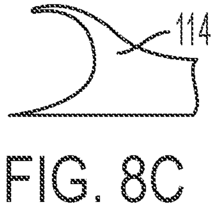

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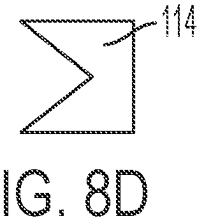

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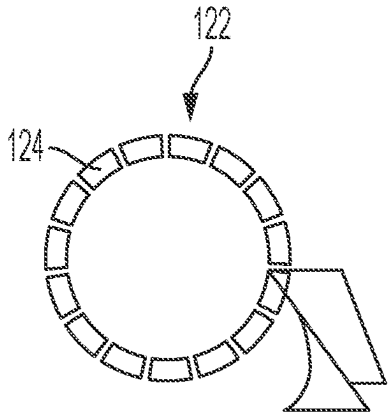

FIG. 9A

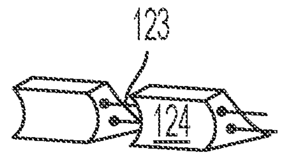

FIG. 9B

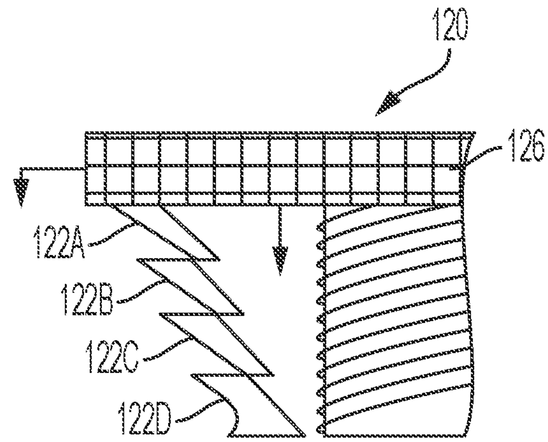

FIG. 9C

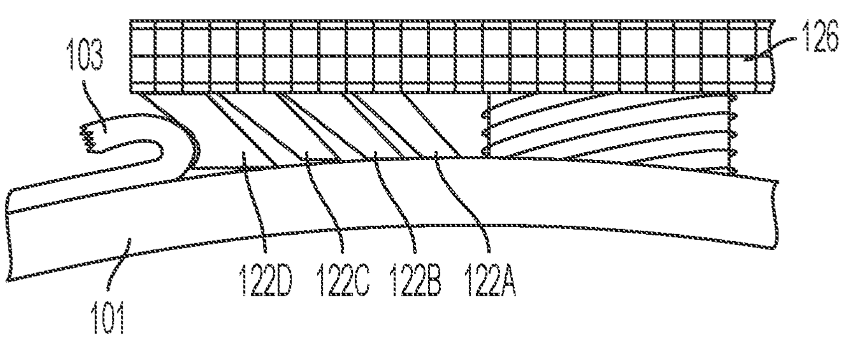

FIG. 9D

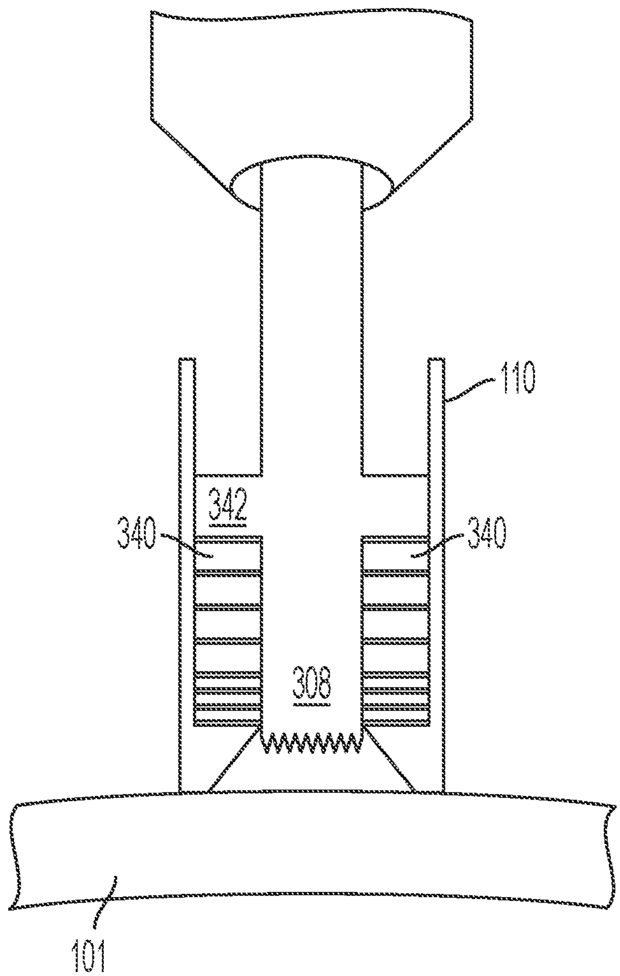

FIG. 10

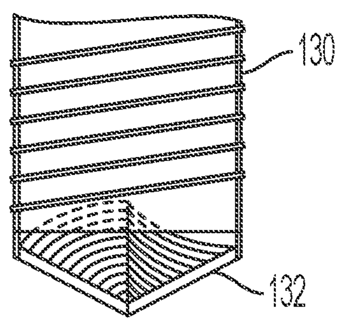

FIG. 11A

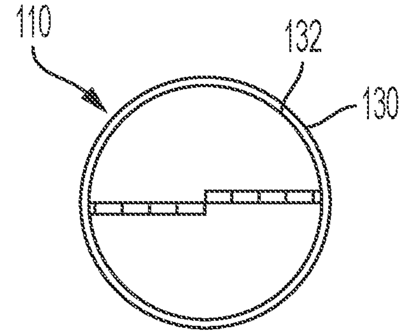

FIG. 11B

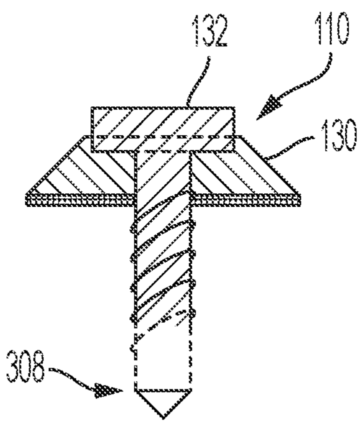

FIG. 11C

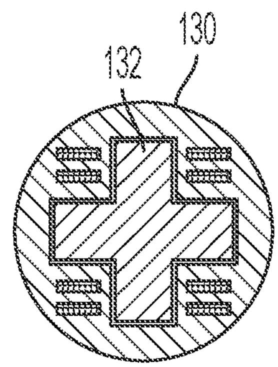

FIG. 11D

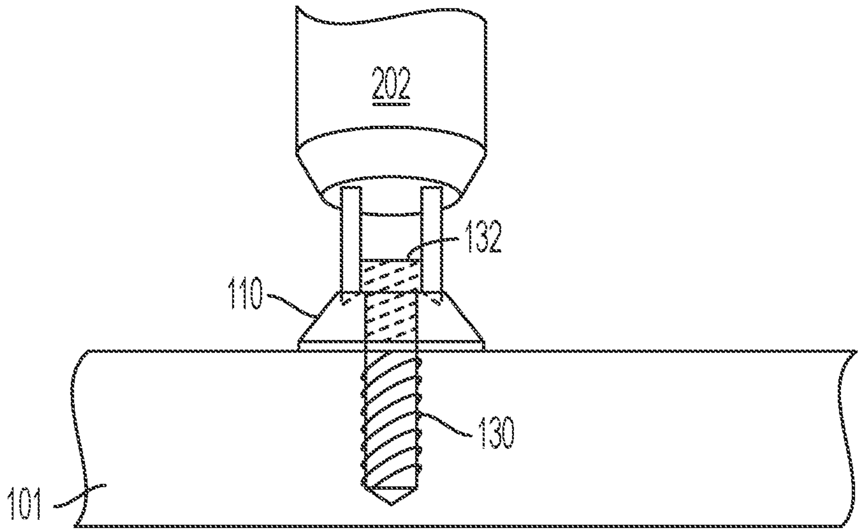

FIG. 12A

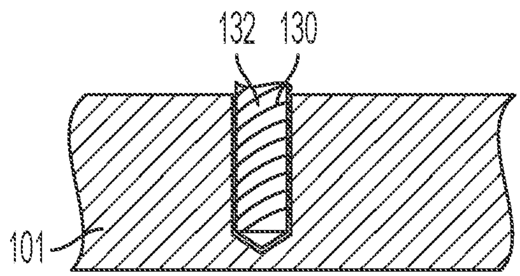

FIG. 12B

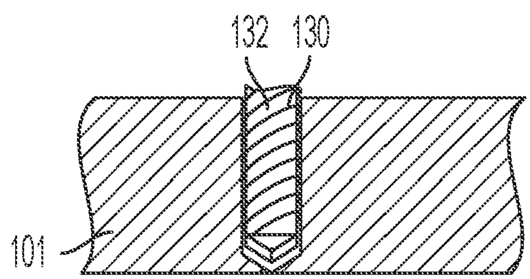

FIG. 12C

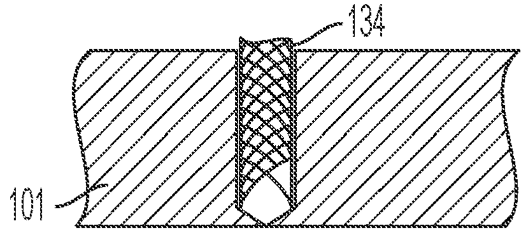

FIG. 12D

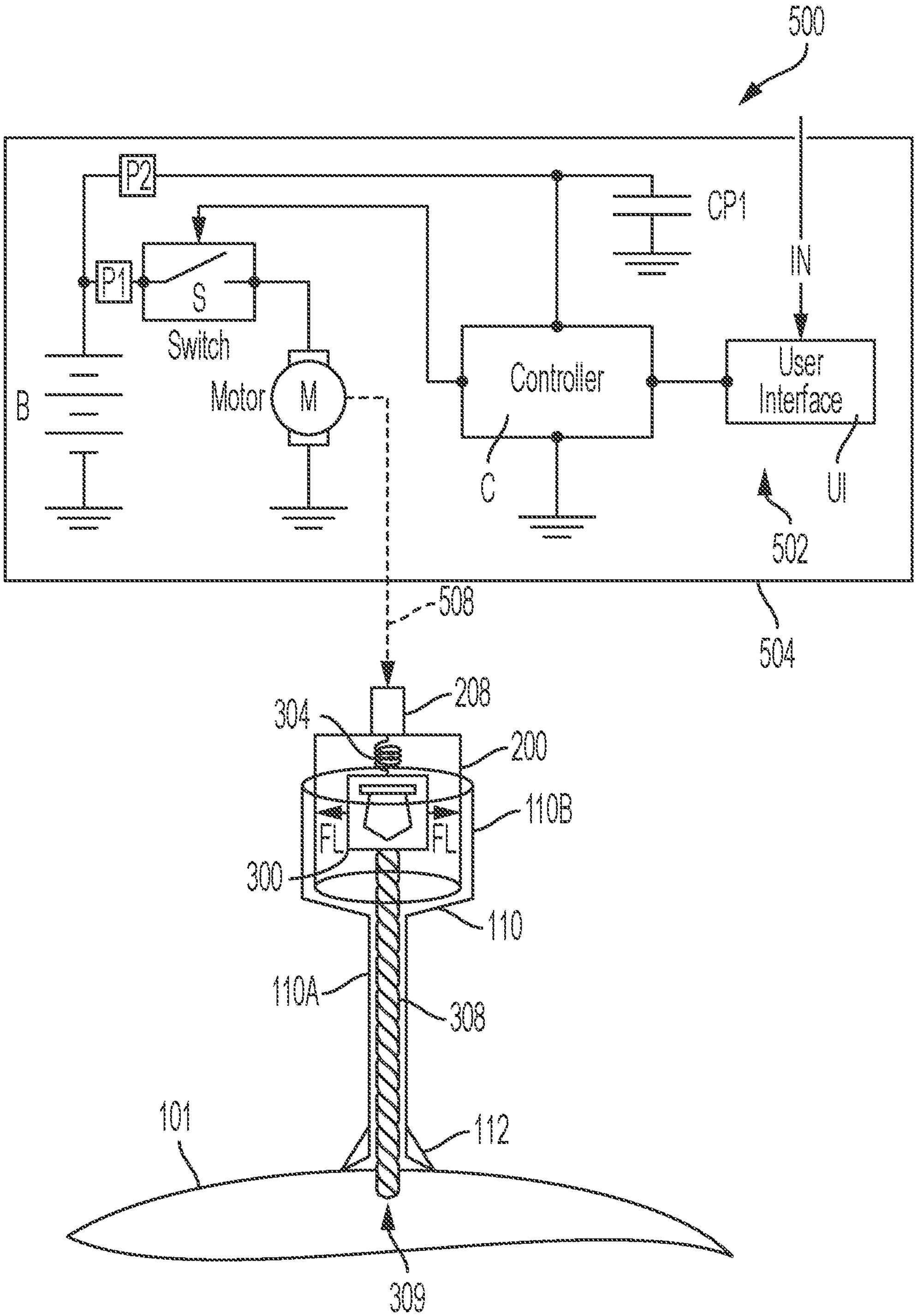
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FIG. 13

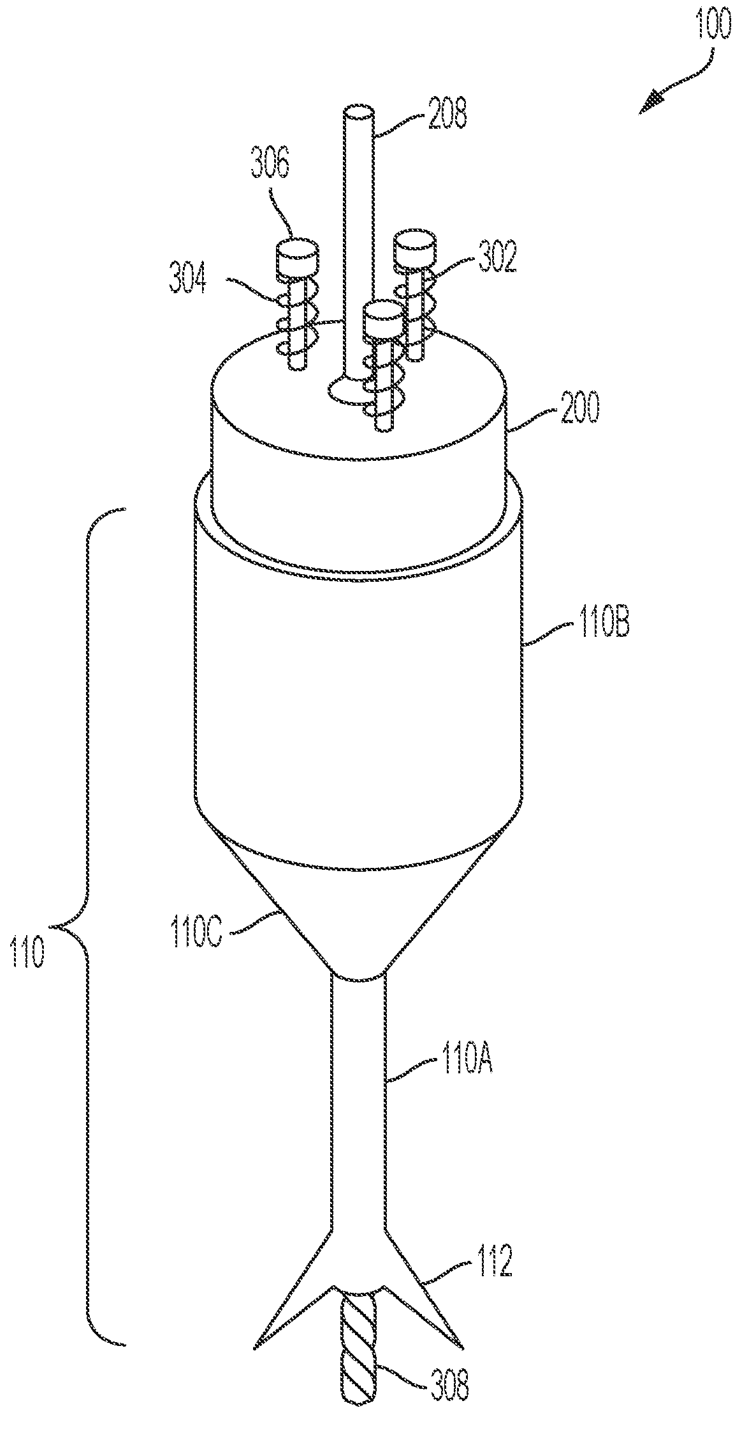

FIG. 14

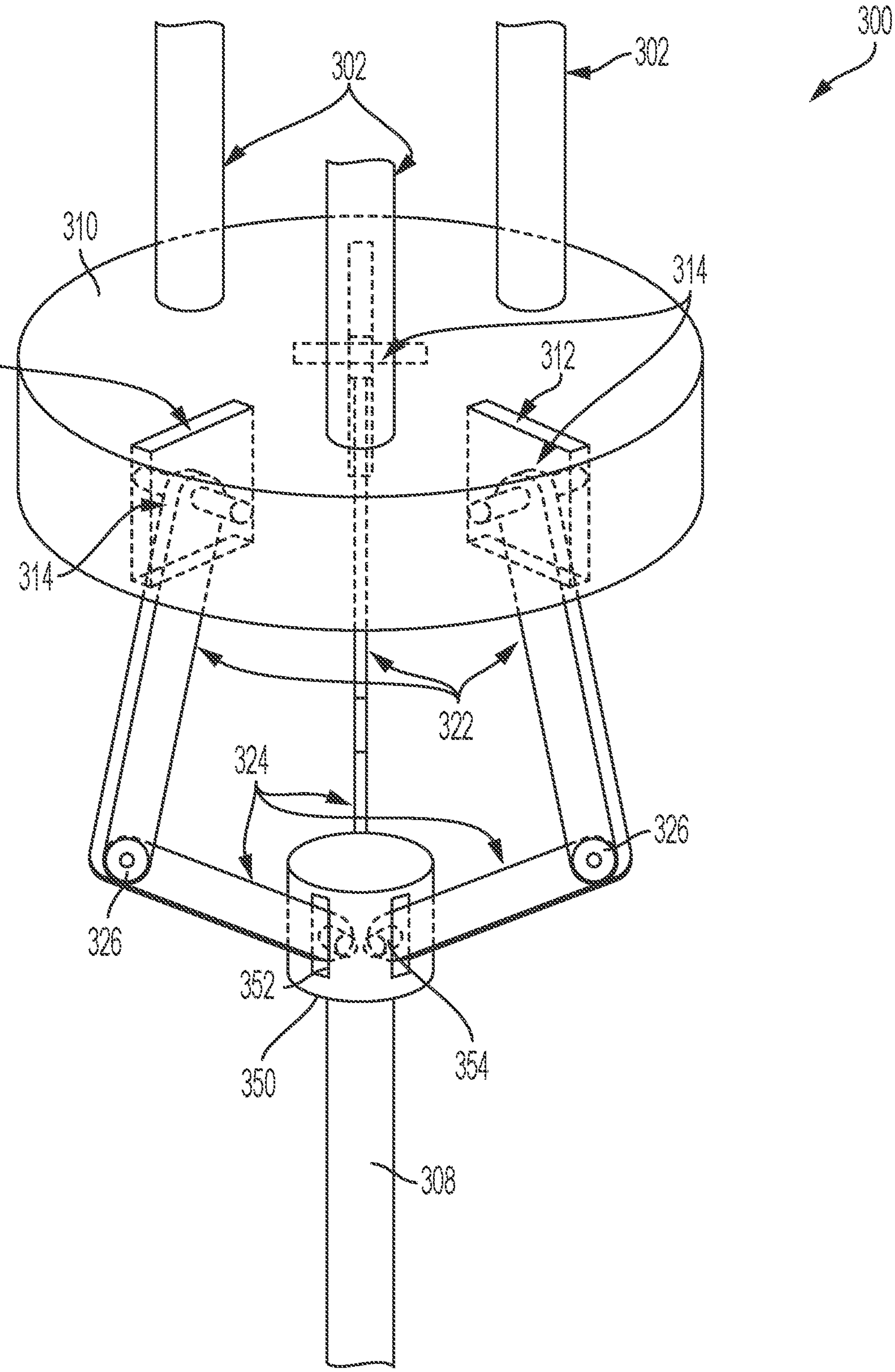

FIG. 15

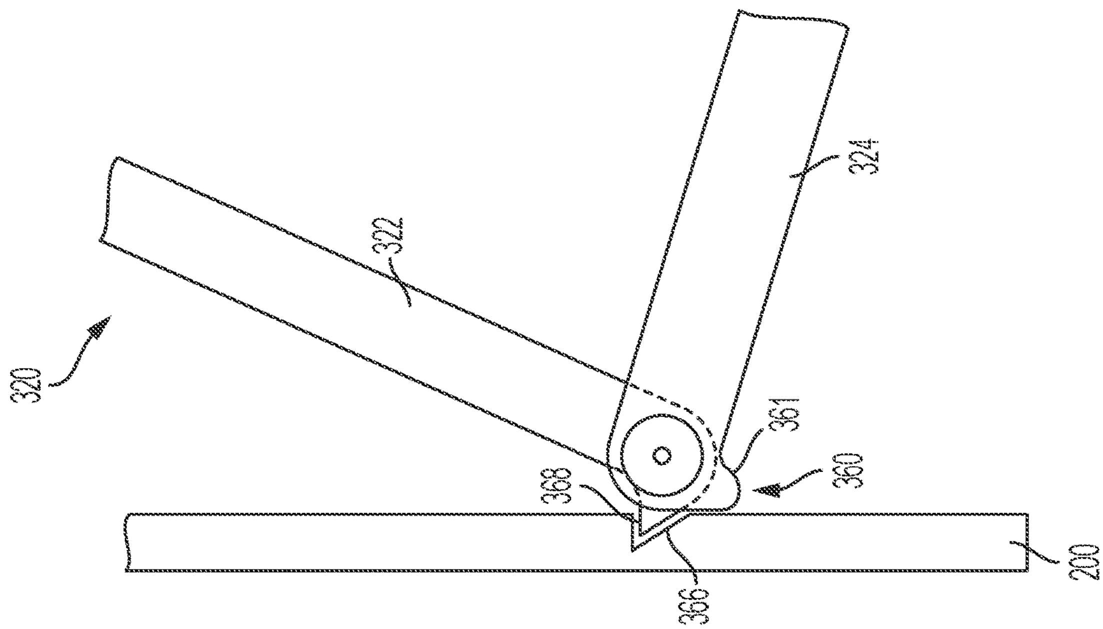

FIG. 16B

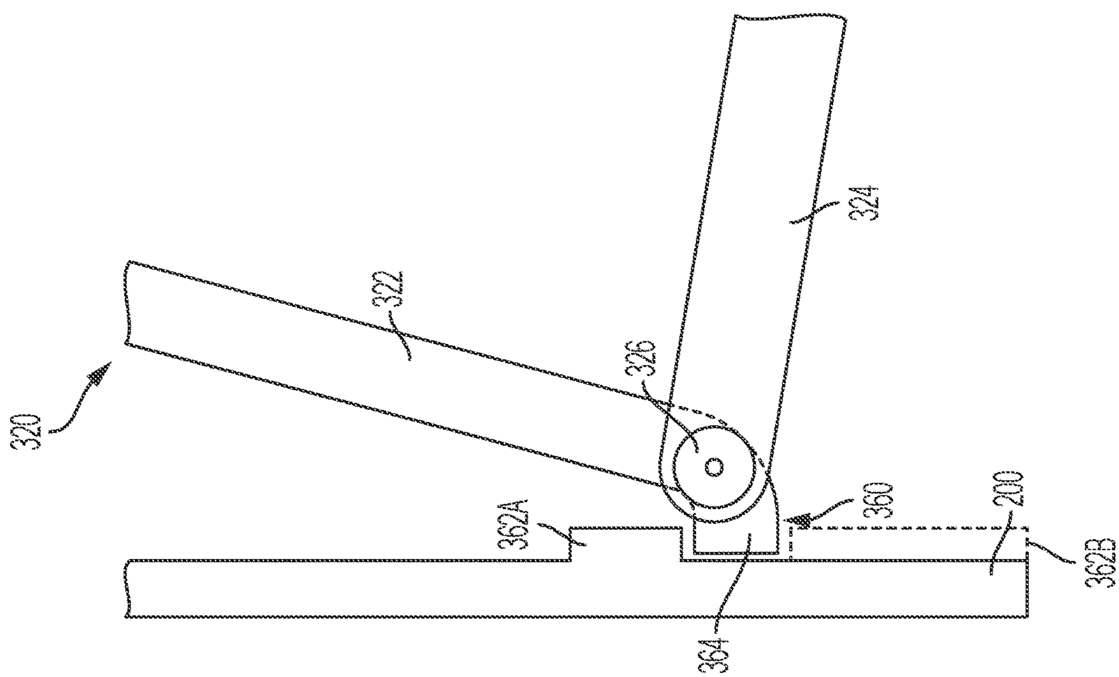

FIG. 16A

SYSTEM AND METHOD FOR INTEGRATED SURGICAL GUIDE-HUB AND DRILL WITH GUIDED DRILLING AND PLUNGE PROTECTION

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a divisional application of U.S. application Ser. No. 17/061,040, filed on Oct. 1, 2020, entitled "System and Method For Integrated Surgical Guide-Hub and Drill with Guided Drilling and Plunge Protection," which is a continuation application of International Application No. PCT/US19/63820, filed on Nov. 28, 2019, which claims the benefit of U.S. Provisional Application No. 62/773,036, filed on Nov. 29, 2018, which applications are hereby incorporated herein by reference in their entirety.

TECHNICAL FIELD

The present invention relates to an integrated surgical guide-hub and drill with guided drilling and plunge protection, and in particular embodiments, integrated component system with a guide-hub, scalp retraction mechanisms, hemostasis mechanisms, catheter guide compatible with a guide-hub, augmented reality tracking and integration, positioning sensors, and tunneling compatible guide-hub.

BACKGROUND

Many medical conditions require access to the brain for the purpose of placing a catheter or electrode. For example, hydrocephalus is a condition where cerebrospinal fluid accumulates in the brain and may lead to a life-threatening pressure increase in the brain. Placement of an external ventricular drain (EVD) is a typical treatment for hydrocephalus. In order to place an EVD, a drill is used to penetrate the skull and a catheter is inserted into to the ventricle in the brain. The drill commonly used today is a hand-crank drill that is guided and controlled by a neurosurgeon's skill and feel. The current procedure is complication prone and often results in a misplaced catheter. A misplaced catheter is ineffective for the EVD, introduces the potential for infection, and may independently cause physical damage to the brain.

There is another device, the Ghajar Guide, that adds components to improve the EVD procedure, but it is only used by a small minority of neurosurgeons due to the additional complexity, components, and steps involved. The Ghajar Guide is not used in the majority of all procedures because surgeons often find it adds complexity and additional steps to the surgery and increases cost.

SUMMARY

In accordance with an embodiment of the present application, a drilling system that includes a guide-hub that includes contact fee and a drilling insert that includes a drill bit and a harness. The contact feet are configured to be placed against a drilling surface to maintain a fixed angle with the drilling surface. The drilling insert is configured to be inserted into the guide-hub and the harness is configured to detect when the drill bit punctures the drilling surface and automatically prevent further drilling.

In accordance to another embodiment of the present application, a drilling system that includes a guide-hub and a drilling insert. The guide-hub includes an upper cylindrical portion and a lower cylindrical portion. The upper cylindrical portion and the lower cylindrical portion having two diameters. The drilling insert includes a harness portion and a drilling portion. The harness portion rotates within the upper cylindrical portion and the drilling portion rotates within the lower cylindrical portion.

In accordance to another embodiment of the present application, a medical tool that includes a cranial access drill. The cranial access drill includes a motor, a guide-hub, a mechanical harness, a drill shaft, and angle alignment feet. The guide-hub includes a retraction portion, a guide portion, and an alignment portion. The mechanical harness rotates inside the retraction portion, and the drill shaft rotates inside the guide portion. The angle alignment feet are coupled to the guide-hub at the alignment portion, and the angle alignment feet maintain an angle of alignment between a drilling surface and the cranial access drill.

In accordance to another embodiment of the present application, a method of using a drilling system includes placing a guide-hub that on a drilling surface, guiding a drilling insert that includes a drill bit and a harness into the guide-hub, drilling the drilling surface with the drill bit, detecting when the drill bit punctures the drilling surface using the harness, and automatically stopping the drilling in response to detecting that the drill bit has punctured the drilling surface. The guide-hub includes an axial direction and the axial direction of the guide-hub is parallel to a surface normal of the drilling surface during drilling.

BRIEF DESCRIPTION OF THE DRAWINGS

For a more complete understanding of the present invention, and the advantages thereof, reference is now made to the following descriptions taken in conjunction with the accompanying drawings, in which:

FIGS. **1**A-**1**D illustrate a high-level sequence of a surgical process in various embodiments;

FIGS. **2**A-**2**D illustrate a detailed sequence of the surgical process in FIGS. **1**A-**1**D;

FIG. **3** illustrates a cross-sectional view of one embodiment of a drilling structure;

FIGS. **4**A and **4**B illustrates a perspective view of an embodiment of a drilling structure;

FIG. **5** illustrates a perspective view of one embodiment of a guide-hub;

FIG. **6** illustrates a perspective view of one embodiment of a catheter guide;

FIG. **7**A illustrates a cross-sectional view of one embodiment of a guide-hub, support legs, and scalp retractors;

FIG. **7**B illustrates a magnified view of the support legs and scalp retractors of the embodiment in FIG. **7**A;

FIG. **8**A illustrates a side view of one embodiment of a guide-hub, guide-hub support legs, and scalp retractors;

FIGS. **8**B-**8**D illustrates various embodiments of the scalp retractors in FIG. **8**A;

FIGS. **9**A-**9**D illustrate multiple view of one embodiment of a scalp retraction mechanism;

FIG. **10** illustrates one embodiment of a guide-hub with plunge protection;

FIGS. **11**A-**11**D illustrate multiple views of one embodiment of a guide-hub;

FIGS. **12**A-**12**D illustrate a process for the guide-hub in FIGS. **11**A-**11**D;

FIG. **13** illustrates one embodiment of a system diagram that includes a control circuit inside a housing and a drilling structure set inside a guide-hub;

FIG. 14 illustrates a perspective view of one embodiment of a drilling structure;

FIG. 15 illustrates a perspective view of one embodiment of a plunge protection harness; and

FIGS. 16A and 16B illustrates magnified views of a joint arm interface.

DETAILED DESCRIPTION OF ILLUSTRATIVE EMBODIMENTS

Currently, the procedure for placing an external ventricular drain (EVD), a life-saving device for removing excess fluid from the brain, uses a hand-powered crank drill to drill through the skull and place a catheter in the ventricle of the brain. The most commonly used hand-crank drill provides no protection for preventing misplacement or plunge. Instead, the hand-powered crank drill relies on neurosurgeon skill and feel. The commonly used hand-crank drill has several problems. Particularly, the commonly used crank drill is hand-powered, has no mechanism to prevent plunging into the brain after puncturing the skull during drilling, has no alignment guide to ensure the proper drilling angle, includes too many components leading to unnecessary complexity, does not include scalp retraction, and does not include any hemostasis mechanism.

As a result of these device shortcomings, the current procedures that use the existing hand-powered crank drill exhibit higher complication rates due to catheter misplacement or other surgeon errors (including plunge). During drilling, the drill is prone to shift drilling angle. Maintaining a perpendicular drilling angle is important for properly placing the catheter in the correct position. Further, maintaining a perpendicular catheter insertion trajectory is also important for properly placing the catheter. Thus, both misaligned holes formed by misaligned drilling and misaligned catheter insertion trajectory can lead to misplacement of the catheter.

Another problem that can arise during drilling occurs as the drill penetrates the skull. If the neurosurgeon applies too much pressure while drilling and does not detect that he or she is about to penetrate the skull, the neurosurgeon may plunge the drill bit into the brain. This type of plunge can result in severe injury, complication, or death.

Various embodiments described herein reduce or prevent catheter misplacement and drill plunge. Both problems, misplacement and plunge, cause substantial complications leading to poor outcomes for patients and increased costs for hospitals. Various embodiments include a guide-hub that maintains both the perpendicular drilling angle and the perpendicular catheter insertion trajectory. Some embodiments also include an automatic plunge protection mechanism (or a harness in multiple embodiments) that withdraws the drill bit automatically as the drill bit penetrates the skull. In addition to these primary problems, various embodiments provide an integrated solution that brings together a complete guide-hub and drill system with other solution elements, including one or more of (1) an electric drill, (2) integrated component system with the guide-hub, (3) a scalp retraction mechanism, (4) a hemostasis mechanism, (5) a catheter guide compatible with the guide-hub, (6) augmented reality tracking and integration for further reducing misplacements, (7) positioning sensors for further reducing misplacements, and (8) a tunneling compatible guide-hub.

In various embodiments, our solution seeks to provide a modern surgical drill that addresses multiple problems in an easy-to-use integrated hub-drill system. Particularly, embodiments include some or all of the following features: (1) reduction of catheter misplacements with a drill guide-hub that maintains drill position and orientation; (2) prevention of plunge with an automatic drill bit plunge protection mechanism; (3) improvement of surgeon efficiency, speed, endurance, and accuracy with an electric power drive system; (4) improvement of surgeon usability (increasing efficiency, speed, and accuracy) with an integrated surgical guide-hub and drill system; (5) improvement of integration with a scalp retraction mechanism integrated directly in the guide-hub; (6) prevention of excessive bleeding, infection, and complications with a hemostasis mechanism; (7) further reduction of catheter misplacements with a catheter guide compatible with the guide-hub; (8) further reduction of catheter misplacements with an augmented reality tracking and integration system; (8) further reduction of catheter misplacements with positioning sensors; and (9) further simplification of surgical procedures with a tunneling compatible guide-hub.

In order to achieve some of these features, various embodiments include precise dimensions. Some embodiments include materials with appropriate coefficients of static friction to enable a friction holding position during drilling that automatically releases after drilling through a hard surface so that automatic drill bit retraction is enabled. Some of these embodiments also include springs for the automatic drill bit retraction with proper spring constants to enable the friction holding position during drilling and the automatic drill bit retraction once puncture occurs. Various embodiment also include one or more of (1) an electric drill, (2) an integrated component system with the guide-hub, (3) a scalp retraction mechanism, (4) a hemostasis mechanism, (5) a catheter guide compatible with the guide-hub, (6) augmented reality tracking and integration for reducing misplacements, (7) positioning sensors for reducing misplacements, and (8) a tunneling compatible guide-hub.

Production of various embodiments can be accomplished in several ways. In a first instance, the parts can be machined by a machinist and assembled into the system. In another instance, the system can be manufactured in an industrial manufacturing process that may include automated assembly, forming or casting components, and any other industrial manufacturing processes. In a further instance, the system can be produced using advanced manufacturing tools such as a 3D printer or computer numerical control (CNC) machines, for example. In short, embodiments can be produced using several techniques known to those of skill in the art. The selection of processes and materials is informed by addressing the issues of biocompatibility, durability, and cost according to embodiments described herein.

Some embodiments are used as a drill to penetrate the skull during surgery. A common procedure that requires a drill for the skull is placement of an EVD, which includes placing a catheter into the brain. An embodiment would be used in such a procedure. The guide-hub would be placed against the skull after the skin is retracted, which may be accomplished through the integrated scalp retraction mechanism. The drill would be guided through the guide-hub to penetrate the skull. Immediately after penetrating the skull, the plunge protection mechanism or harness would prevent the drill bit from plunging into the brain. Then, the drill is removed from the guide-hub and a catheter guide is used with the guide-hub to maintain the position and alignment of the catheter as it is inserted into the brain. Other features or components of the solution may be used along with this process as described further herein.

A schematic embodiment of a method of a surgical process will be first described using FIGS. 1A-1D and a detailed embodiment of a method of a surgical process will be described using FIGS. **2**A-**2**D. A detailed embodiment of a drilling structure will be described using FIG. **3** and alterative embodiments of a drilling structure will be described using FIGS. **4**, **13** and **14**. An embodiment of a guide hub will be described using FIG. **5**, alternative embodiments of a guide-hub will be described using FIGS. **7**A-**7**B, **8**A-**8**D, **10**, and **11**A-**11**D, and a schematic embodiment of a method of using an alternative guide-hub using FIG. **12**A-**12**D. An embodiment of a catheter guide will be described using FIG. **6**. A detailed embodiment of a scalp retractor will be described using FIGS. **9**A-**9**D. A detailed embodiment of a plunge protection harness will be described using FIG. **15**.

FIGS. **1**A, **1**B, **1**C, and **1**D illustrate a high-level sequence of a surgical process in various embodiments. In FIG. **1**A, the scalp is opened and a guide-hub **110** is placed on a skull **101**. The support legs **112** of the guide-hub **110** are placed against the skull **101** and maintain a perpendicular alignment. In FIG. **1**B, a drill bit **308** supported by a central drill shell **200** is aligned inside the guide-hub **110** and drilling is performed with perpendicularity maintained by the guide-hub **110**. The guide-hub **110** is omitted from FIG. **1**B for simplicity of illustration. In FIG. **1**C, as a drill bit **308** penetrates the skull **101**, a plunge protection harness **300** detects when the drill bit **308** punctures the skull **101** and retracts the drill bit **308** automatically or prevents further plunge. The plunge protection harness **300** is omitted from FIG. **1**C for simplicity of illustration. In FIG. **1**D, a catheter guide **400** is inserted inside the guide-hub **110** and used to guide the catheter **402** for accurate placement. The guide-hub **110** maintains the perpendicular alignment of the catheter guide **400**, which ensures perpendicular catheter trajectory and reduced misplacement of the catheter **402**.

FIGS. **2**A, **2**B, **2**C, and **2**D illustrate each of the four steps of FIGS. **1**A, **1**B, **1**C, and **1**D in detail. FIG. **2**A illustrates accessing a skull **101**, where a guide-hub **110** is placed against the skull **101** after an incision is made in the scalp **103**. The guide-hub **110** includes support legs **112** for contacting the skull **101** (contact feet) and scalp retractors **114** extending from the support legs as feet extensions for holding back the scalp **103**. The scalp retractors **114** include a homeostasis mechanism to reduce bleeding from the scalp. One example of the homeostasis mechanism is pressure clips that apply clamping pressure on the scalp. In alternative embodiments, the scalp retractors or homeostasis mechanism are omitted.

FIG. **2**B illustrates aligning the drill **202** and drilling through the skull **101**. The guide-hub **110** maintains the perpendicularity with the skull **101** while the drill **202** is guided through the guide-hub **110**. The central drill shell **200** spins inside the guide-hub **110**. A motor or drill drives the rotation of the central drill shell **200**. The drill or motor is omitted from this illustration for simplicity.

FIG. **2**C illustrates a plunge protection harness **300**. Before pressing the drill bit tip **309** against the skull **101**, a joint shoulder **310** is depressed. The joint shoulder **310** support joint arms **320**, passes through the central drill shell **200**, and is in contact with a spring **304**. Depressing the joint shoulder **310** compresses the spring **304** and extends the drill bit **308** supported by the joint arms **320** downwards. As the drill bit tip **309** is in contact with the skull **101** and pressure is applied, the joint arms **320** supporting the drill bit **308** expand outward and lock into position on the internal wall of the central drill shell **200** due to friction. The lock with the internal wall due to friction prevents the spring **304** from returning the joint shoulder **310** to its neutral position. As long as the pressure is maintained, the friction between the internal wall of the central drill shell **200** and the supporting joint arms **320** prevents the spring force F_S from retracting the joint shoulder **310**, joint arms **320**, and drill bit **308**. As soon as the drill bit **308** penetrates the skull **101**, the counteracting force on the drill bit tip **309** ceases. Because the force on the drill bit tip **309** disappears, the horizontal forces maintaining the lock due to friction between the joint arms **320** and the internal wall of the central drill shell **200** is lost. Thus, the spring force F_S will automatically withdraw the joint shoulder **310**, joint arms **320**, and drill bit **308** once skull penetration is achieved.

According to various embodiments, in order to allow the spring force F_S to withdraw the joint shoulder **310**, joint arms **320**, and drill bit **308** immediately upon penetrating the skull **101**, the force downward driving the drill pressure, the drill force F_D, is applied to the central drill shell **200** but not to the joint shoulder **310** and spring **304**. As shown in FIG. **2**C, the drill force F_D is applied to the central drill shell **200** but not to the joint shoulder **310** connected to the joint arms **320**. In this way, the drill force F_D is transmitted to the drill bit **308** through the central drill shell **200**, the lock caused by friction, and the lower joint arms **324**. Thus, as soon as the lock caused by friction between the joint arms **320** and the internal wall of the central drill shell **200** is released, the drill force F_D is decoupled from the drill bit **308**.

FIG. **2**D illustrates guiding the catheter trajectory with a catheter guide **400** that is inserted into the guide-hub **110** once the central drill shell **200** (not shown in FIG. **2**D) is removed. After penetrating the skull **101**, the central drill shell **200** (not shown in FIG. **2**D) with the plunge protection harness **300** and drill bit **308** are removed from the guide-hub **110**. In place of the central drill shell **200**, the catheter guide **400** is inserted into the guide-hub **110**. The catheter guide **400** maintains the perpendicularity of a catheter **402** during insertion by referencing the alignment of the guide-hub **110** that is maintained by the support legs **112** set against the skull **101**. Using this solution, the perpendicularity of the drilling and the catheter placement is improved. Further, the plunge protection harness **300** prevents injury, complication, and death from over-drilling and plunging of the drill bit **308**. The scalp retractors **114** integrated into the guide-hub **110** simplify the surgical sequence and maintain component alignment and integrity. The homeostasis mechanism reduces bleeding to further prevent complications. In other embodiments, the catheter guide **400** is integrated into the guide-hub **110** such that there is not a separate insertion step of the catheter guide.

FIG. **3** illustrates a zoomed in cut-away of a drilling structure **100** which includes a central drill shell **200** and a plunge protection harness **300** within the central drill shell **200** as described in reference to FIGS. **2**A, **2**B, **2**C, and **2**D, but FIG. **3** includes more detail and a different arrangement of some portions. The joint shoulder **310** still supports the joint arms **320**, which support the drill bit **308**. However, the joint shoulder **310** is coupled to two support shafts **302** that each have a restoring spring **304** in this instance. With this configuration, the drill **202** can drive a central drive shaft **208** that supports and drives the central drill shell **200**.

FIG. **4**A illustrates a perspective view of a more detailed drilling structure **100** which includes the central drill shell **200** and the plunge protection harness **300** as described in reference to FIGS. **2**A, **2**B, **2**C, **2**D, and **3**, but FIG. **4**A includes more detail and a different arrangement of some portions according to various embodiments. As shown, the joint shoulder **310** is a 3D piece that includes and supports three sets of joint arms **320** extending to a drill bit structure

330. Each of the joint arms 320 includes a lower joint arm 324 and an upper joint arm 322. The drill bit structure 330 may include a joint receiver portion 332 and an insert portion 334 for attaching a drill bit 308 (which could be threaded, for example). In FIG. 4B, the drill bit structure 330 may be a single fabricated piece with the joint receiver portion 332 integrated with the drill bit 308. In some particular embodiments, the single fabricated piece includes the drill bit 308 embedded into the joint receiver 332 as a unitary piece.

The central drill shell 200 is a cylinder with a top surface that has three holes for extending support shafts 302 through the holes to the joint shoulder 310. The three support shafts 302 each have stoppers 306 that couple a spring 304 to the shaft and lock the three springs 304 on the three support shafts 302 between the stoppers 306 and the top surface of the central drill shell 200. The support shafts 302 extend to and support the joint shoulder 310. The top surface of the central drill shell 200 also includes a central drive shaft 208 extending upward. The central drive shaft 208 is connected to a drill drive, such as an electric drill motor, or another motor that causes the central drill shell 200 to spin. A hand powered drill drive is used in alternative embodiments. The central drive shaft 208 may have a hexagonal cross-section, as shown, or other shapes for coupling to the drill drive.

As described further hereinabove, the joint arms 320 extend outward and lock into place, with a friction lock, against the internal wall of the central drill shell 200 when the drill bit 308 is pressed against the skull 101 during drilling. Thus, the drill force F_D applied to the central drive shaft 208 by the drill drive is transmitted to the drill bit 308 through the central drill shell 200 wall, the friction lock, and the lower joint arms 324 that are connected to the joint receiver portion 332 of the drill bit structure 330.

FIG. 5 illustrates a perspective view of a guide-hub 110 showing additional detail and a different arrangement of some portions. The guide-hub 110 is set against the skull 101 and maintains perpendicularity with the skull 101 as described hereinabove in reference to FIGS. 1A, 1B, 1C, 1D, 2A, 2B, 2C, and 2D. The guide-hub 110 receives a central drill shell 200 and maintains perpendicularity of the central drill shell 200 and drill bit 308 during drilling. After the drill bit 308 penetrates the skull 101 and drilling is complete, the guide-hub 110 receives a catheter guide 400 and maintains perpendicularity of the catheter trajectory during catheter placement. In other embodiments, the guide-hub 110 includes an integrated catheter guide 400 that is not removed during drilling and is used after drilling to guide the catheter 402 into place. The guide-hub 110 may also include additional attachments as described further herein, but those attachments are omitted from FIG. 5 for simplicity of illustration.

FIG. 6 illustrates a perspective view of a catheter guide 400. In some embodiments, the catheter guide 400 is inserted into the guide-hub 110 after the central drill shell 200 is removed. The catheter guide 400 conveys the perpendicular alignment reference of the guide-hub 110 to the catheter 402 and maintains the perpendicularity of the catheter 402 during insertion. By maintaining a perpendicular trajectory during catheter insertion, catheter misplacement is prevented, avoiding complications such as ineffective treatment and infection, for example. The catheter guide 400 may be similar in height to the guide-hub 110 (as shown in FIG. 2D) or may have a much lower profile as shown here in FIG. 6. In another instance of our solution the catheter guide 400 includes a depth gauge for further improving placement accuracy.

FIGS. 7A and 7B illustrate a cross-sectional and expanded view of support legs 112 and scalp retractors 114 according to some embodiments. In such embodiments, the support legs 112 set against the skull 101 and include scalp retractors 114 on hinges at the ends of the support legs 112. As the support legs 112 are placed on the skull 101, the scalp retractors 114 catch the scalp 103 and other tissues, such as the periosteum membrane, and hold the scalp 103 away from the drilling location. This additional solution also may include ball bearings 118 between the guide-hub 110 and the central drill shell 200 as shown. In some embodiments, the joint 116 in the support legs 112 (contact feet) connecting the support legs 112 to the scalp retractors 114 (feet extensions) may be a joint or hinge that has high friction or may be a spring joint as shown in FIG. 7B. In other embodiments, the hinge may have less friction or be another type of joint or hinge.

FIG. 8A illustrates a side view of support legs 112 according to another embodiment. The support legs 112 are attached to the guide-hub 110 as described herein, but in this embodiment, the support legs 112 are made of a resilient material or structure. Thus, the support legs 112 expand outward as the guide-hub 110 is pressed against the skull 101. FIGS. 8B, 8C, and 8D also illustrate alternative scalp retractor 114 pieces for attachment to the end of the support legs 112.

FIGS. 9A, 9B, 9C, and 9D illustrate a scalp retractor 114 according to another embodiment. FIG. 9A illustrates a top view of an interlocking ring 122 and its spacers 124. FIG. 9B illustrates a perspective view of spacers 124 connected by stretchable or elastic materials 123 of an interlocking ring 122. FIG. 9C illustrates a front view of the scalp retractor 114 which is provided by a series of interlocking rings 122 around a guide-hub 110. As the interlocking rings 122 are pushed downward, each interlocking ring 122 slides inside the interlocking ring 122 below it and forces the ring below it to expand outward, which in turn forces the ring below that ring to also expand outward and so on. In this embodiment, the first interlocking ring 122A pushes the second interlocking ring 122B down, which pushes the third interlocking ring 122C down, which pushes the fourth interlocking ring 122D. As the fourth interlocking ring 122D is pushed, it expands outward along the skull 101 and retracts the scalp 103. FIG. 9D illustrates a front view of a compressed scalp retractor 114 of FIG. 9C. The rings are pushed down by a structure that can slide downwards and can be locked in place by applying a force to the topmost interlocking ring 122. In the solution illustrated in FIGS. 9C-9D, the structure is a large ring 126 that twists on threading on the outside of the guide-hub 110.

The number of interlocking rings 122, illustrated as four, may be larger or smaller in different solution instances. The interlocking rings 122 are expandable. As shown in FIGS. 9A and 9B, the rings are connected by a stretchable or elastic material 123. In another solution, the interlocking rings could use an expandable sliding ring structure that is not elastic but is capable of expansion.

FIG. 10 illustrates a cross-sectional view of an alternative embodiment of a guide-hub 110 with plunge protection. In such alternative embodiments, plunge protection is provided by a series of drill depth spacers 340 (as opposed to the plunge protection harness 300 described hereinabove). The drill bit 308 includes an expanding stop portion 342 that prevents further drill penetration once the stop portion 342 on the drill bit 308 contacts the topmost drill depth spacer 340. The drill depth spacers 340 are contained in the guide-hub 110 and can be individually removed or realigned to allow the stop portion **342** on the drill bit **308** to continue progressing downward while drilling. The drill depth spacers **340** serve as mechanical stops that prevent plunge once the skull is penetrated by the drill bit **308**.

According to some embodiments as shown in FIG. **10**, the drill depth spacers **340** can have two different thicknesses, a thicker spacer for initial drilling and a thinner spacer for later drilling as the drill bit approaches the other side of the skull bone and is close to penetrating the skull. In other solutions, the spacers could have the same thickness or multiple (more than two) different thicknesses.

FIGS. **11**A, **11**B, **11**C, and **11**D illustrate a guide-hub **110** according to an alternative embodiment. In this embodiment, the guide-hub **110** includes a threaded hollow sheath **130** and an internal cut and drive shaft **132**. FIG. **11**A illustrates a front view of the threaded hollow sheath **130** and an internal cut and drive shaft **132**. FIG. **11**B illustrates a bottom view of the guide-hub **110**. FIG. **11**C illustrates a front view of the guide-hub **110** with the threaded hollow sheath **130** and internal cut and drive shaft **132**. FIG. **11**D illustrates a top view of the guide-hub **110**. The internal cut and drive shaft **132** and the threaded hollow sheath **130** of the guide-hub **110** are drilled into the skull **101** until the threads of the threaded hollow sheath **130** are secured in the skull. The drill continues drilling until the internal cut and drive shaft **132** penetrates the skull. The internal cut and drive shaft **132** is then removed from the guide-hub **110** and a catheter **402** is inserted through the threaded hollow sheath **130** of the guide-hub **110**.

FIGS. **12**A, **12**B, **12**C, and **12**D illustrate a process for the guide-hub **110** embodiment described in reference to FIGS. **11**A, **11**B, **11**C, and **11**D. As shown in FIG. **12**A, a drill **202** drives the guide-hub **110** with the threaded hollow sheath **130** and the internal cut and drive shaft **132** into the skull **101**. The threads of the threaded hollow sheath **130** grip into the skull **101**. In FIG. **12**B, the drilling continues until the internal cut and drive shaft **132** is close to penetrating the skull **101**. In FIG. **12**C, the internal cut and drive shaft **132** can be removed right before penetrating the skull **101**. In FIG. **12**D, a cutting piece **134**, for example, a sharp wire, is used to break through the last part of the skull, e.g., the bone shelf after drilling. A catheter **402** is then inserted through the hollow portion of the guide-hub **110**.

FIG. **13** illustrates a system diagram **500** according to various embodiments that includes a control circuit **502** inside a housing **504** and a central drill shell **200** set inside the guide-hub **110**. In such embodiments as illustrated in FIG. **13**, motor M supplies output shaft drive power **508** to the central drive shaft **208** of the central drill shell **200**. Motor M is controlled by a switch S. The switch S is activated to supply power P**1** to motor M from a power supply, such as a battery B, as illustrated in FIG. **13**. In some embodiments, the switch S is controlled by a controller C that receives user input IN through the user interface UI.

In various embodiments, user input IN may be through a button, switch, or trigger. In some such embodiments, the user interface UI includes the button, switch, or trigger. User input IN may be an on or off signal. In other embodiments, user input IN is a more complex signal that can take on many values to provide variable control. The user interface may include an analog interface circuit. The controller C may be a microcontroller, an analog control circuit, or a digital control circuit. In some embodiments, power circuit P1 or power circuit P**2** is included. Power circuit P1 and power circuit P**2** provide voltage conversion or regulation. For example, in some embodiments, power circuit P**2** converts the voltage supplied by the battery to a first voltage to supply the controller, and power circuit P**1** converts the voltage supplied by the battery to a second voltage to supply motor M. In some embodiments, the first voltage and the second voltage are different voltages. In alternative embodiments, the first voltage and the second voltage are the same voltage. Power circuit P**1** and power circuit P**2** include voltage regulation circuits in some embodiments. In further embodiments, power circuit P**1** and power circuit P**2** are omitted.

In some embodiments, power regulation capacitor CP**1** is included to stabilize the power supply to the controller C or to motor M. In alternative embodiments, power regulation capacitor CP**1** is omitted. The battery may be another type of power supply, such as a wired power supply. In some embodiments the battery is rechargeable. In various embodiments, the battery is not rechargeable. In further embodiments, the battery or power supply is provided through a supercapacitor.

According to various embodiments, motor M drives the central drive shaft **208** of the central drill shell **200**. Motor M may be controlled to provide variable rotations per minute (RPM) to the central drive shaft **208** in some embodiments. In other embodiments, motor M is controlled to provide variable torque to the central drive shaft **208**. As the central drive shaft **208** is driven by motor M, the central drill shell **200** rotates. Inside the central drill shell **200**, the plunge protection harness **300** is coupled to the central drill shell **200** such that the plunge protection harness **300** and the drill bit **308** attached to the plunge protection harness **300** also rotate. In such embodiments, the drill bit **308** is driven to rotate and drill into the drilling surface. In some embodiments, the drilling surface is a skull **101** and the drilling is performed as part of a cranial access procedure. For example, one such procedure involves the placement of an EVD for treatment of hydrocephalus.

In various embodiments, the plunge protection harness **300** is coupled to the central drill shell **200** through friction lock FL. In some embodiments, friction lock FL functions by the plunge protection harness **300** expanding outward to press against the inner wall of the central drill shell **200**. The inner wall of the central drill shell **200** includes a rough surface, a high friction surface, a ribbed surface, or one or more ridges in various embodiments. In such embodiments, friction lock FL is strengthened by the rough surface, the high friction surface, the ribbed surface, or the one or more ridges. According to various embodiments, the plunge protection harness **300** engages the friction lock FL when a counter force is provided against the drill bit **308** that pushes the plunge protection harness **300** upward. The counter force is present when the drill bit **308** is pressed against a hard surface, such as when the drill bit **308** is pressed against the drilling surface during drilling. As soon as the drilling surface is punctured, the drill bit **308** breaks through the drilling surface and the counter force is removed. In such embodiments, the plunge protection harness **300** disengages friction lock FL and withdraws the drill bit **308** automatically due to the spring **304**. The spring **304** is set to a compression state before the plunge protection harness **300** engages friction lock FL and the counter force is applied to the drill bit **308**. Thus, once the plunge protection harness **300** disengages friction lock FL due to puncture, the drill bit **308** is automatically withdrawn by the springs **304** restoring force. Note that FIG. **13** represents the plunge protection harness **300** and spring **304** schematically for simplicity of illustration. The details of plunge protection harness **300** and spring **304** are included and describe in reference to the other figures herein, such as in FIG. **14** and FIG. **15**, for example. In alternative embodiments, spring **304** may be configured to be set in an extension state instead of a compression state before friction lock FL is engaged.

According to various embodiments, the central drill shell **200** rotates inside the guide-hub **110** during drilling. The guide-hub **110** includes support legs **112** set against the drilling surface. The guide-hub **110** maintains a set drilling angle with the drilling surface due to the support legs **112**. In such embodiments, the support legs **112** are rigidly set against the drilling surface and the guide-hub **110** prevents the drill bit **308** from altering the drilling angle during drilling. Thus, the set drilling angle is maintained throughout drilling. In various embodiments, the drilling angle is set such that the drill bit **308** is perpendicular to the drilling surface. In other embodiments, the drilling angle is set so that the drill bit **308** is within 10° of perpendicular, i.e., the drill bit **308** is maintained between 80° and 100° of the drilling surface.

In various embodiments, the drill bit **308** is guided by the lower portion **110**A of the guide-hub **110**, which has a diameter slightly larger than the drill bit **308**. The upper portion **110**B of the guide-hub **110** has a larger diameter that is large enough to receive the central drill shell **200** that contains the plunge protection harness **300**. According to such embodiments, the lower portion **110**A of the guide-hub **110** guides the drill bit **308** and sets the support legs **112** against the drilling surface with a smaller footprint than the upper portion **110**B of the guide-hub **110**. In such embodiments, the guide hub **110** has a first smaller diameter for the lower portion **110**A and a second larger diameter for the upper portion **110**B. In some embodiments, the first smaller diameter is less than 4 cm and the second larger diameter is greater than or equal to 4 cm. In particular embodiments, the first smaller diameter is less than or equal to 2 cm and the second larger diameter is between 2 cm and 6 cm. In some embodiments, the second larger diameter may be sized so as to be comfortably gripped in a surgeon's hand. According to a particular embodiment, the first inner diameter is small enough that the support legs **112** may be placed against the skull **101** through an incision in the scalp **103** that is approximately 2 cm.

In various embodiments, the drill bit tip **309** is an abrasive tip. In other embodiments, the drill bit tip **309** is a cutting tip. The drill bit tip **309** is hollow with an abrasive or cutting edge around the diameter of the drill bit tip **309** in some embodiments. In various different embodiments, the drill bit **308** and drill bit tip **309** may include a twist bit, a unibit, a hole saw, a coated abrasive bit, a center drill bit, a core drill, a spade bit, a lip and spur drill bit, an augur bit, a center bit, or a Forstner bit. Particular embodiments without a sharp tip may advantageously reduce complication rates. For example, an abrasive tip, a core drilling tip, or a Forstner bit may provide reduced complication rates.

According to various embodiments, once the drill bit tip **309** punctures the drilling surface and the plunge protection harness **300** retracts the drill bit **308**, the central drill shell **200** with the plunge protection harness **300** and drill bit **308** may be removed from the guide-hub **110**. Following removal of these pieces, a catheter **402** may be introduced into the area beneath the drilling surface as described further hereinabove in reference to, for example, FIG. **1**D and FIG. **2**D. The smaller diameter of the lower portion **110**A of the guide-hub **110** may serve as a catheter guide **400**. In other embodiments, an additional catheter guide **400** may be inserted into the guide-hub **110** to guide the catheter placement. According to various embodiments, the guide-hub **110** guides the catheter placement such that the angle between the drilling surface and the catheter **402** is maintained at the set angle described hereinabove in reference to the drill bit **308** in FIG. **13**. In alternative embodiments, the catheter **402** is set to an angle different from the angle of the drill bit **308**.

In some alternative embodiments, motor M and the control elements are replaced with a hand crank mechanism controlled by the operator, such as a surgeon. In other alternative embodiments, plunge protection operates without a friction lock FL and includes a torque change sensing element that detects a change in torque corresponding to puncturing the drilling surface. The detected torque change is used to activate the plunge protection harness **300** to withdraw the drill bit **308**. In various embodiments, Controller C is configured to detect a voltage change at Motor M that corresponds to puncturing the drilling surface. In particular such embodiments, Controller C deactivates Motor M when puncturing the drilling surface is detected.

FIG. **14** illustrates a perspective view of the drilling structure **100** according to various embodiments. The drilling structure **100** includes the central drill shell **200**, the guide-hub **110**, and the drill bit **308** (which is attached to elements inside the central drill shell **200** as described hereinbelow in reference to FIG. **15**). As described in detail in reference to FIG. **13**, the central drill shell **200** rotates inside the guide-hub **110** due to a driving force applied by a motor (not shown in FIG. **14**) to the central drive shaft **208** at the top-most portion of the central drill shell **200**. According to some embodiments, the central drill shell **200** includes springs **304** as part of the plunge protection harness **300** (described in reference to FIG. **13** hereinabove and in more detail in reference to FIG. **15** hereinbelow). In such embodiments, the springs **304** are set between the top surface of the central drill shell **200** and stoppers **306** on support shafts **302** (support shafts **302** extend inside the central drill shell **200**). The support shafts **302** attach to the joint shoulder **310** (illustrated and described hereinbelow in reference to FIG. **15**) and, together with the springs **304** and joint arms **320** (illustrated and described hereinbelow in reference to FIG. **15**), form the plunge protection harness **300**. The springs **304** illustrated in FIG. **14** are compressed before friction lock FL is engaged. In such embodiments, the springs **304** restoring force after puncture (when the counter force on the drill bit **308** is removed) is due to compression of the springs **304**. In alternative embodiments, the springs **304** may be configured to be set in an extension state instead of a compression state before friction lock FL is engaged. In some such embodiments, the springs **304** would be arranged inside central drill shell **200** (not shown), underneath the top surface instead of on top of the top surface (as shown) of central drill shell **200**.

In some embodiments, the guide-hub **110** includes a tapered portion **110**C from the lower portion **110**A of the guide-hub **110** to the upper portion **110**B of the guide-hub **110** as illustrated. In other embodiments, the tapered portion **110**C is omitted and the transition between the lower portion **110**A and the upper portion **110**B is a flat portion perpendicular to the outer cylindrical surfaces (not shown). In various embodiments, the guide-hub **110** includes three support legs **112** at the bottom, of which only two support legs **112** are visible in the perspective view of FIG. **14** (the third is hidden behind the drill bit **308**). In other embodiments, four or five support legs **112** are included in the guide-hub **110**. In still further embodiments, more than five support legs **112** are included. In a particular alternative embodiment, only two support legs **112** are included. In this particular alternative embodiment, the angle setting functionally for the drill bit **308** and the catheter **402** placement is limited.

FIG. **15** illustrates a cut-away view showing portions of the plunge protection harness **300** included inside the central drilling shell **200** according to various embodiments as described hereinabove in reference to FIG. **13** and FIG. **14**. In such embodiments, the support shafts **302** are connected to and support the joint shoulder **310**. The support shafts **302** extend downward from outside the central drill shell **200**, where the support shafts **302** are coupled to the central drill shell **200** through the springs **304**, as described hereinabove in reference to FIG. **14**. The joint shoulder **310** supports the joint arms **320**, drill bit coupling **350**, and drill bit **308**.

According to various embodiments, the joint shoulder **310** includes upper joint arm slots **312** where the joint arms **320** hang down from the joint shoulder **310** and each include an upper joint arm **322** and a lower joint arm **324** coupled through a joint hinge **326**. The upper joint arms **322** are connected to joint shoulder hinges **314** inside the upper joint arm slots **312** of the joint shoulder **310**. The lower joint arms **324** are coupled to the drill bit coupling **350** through coupling hinges **354** inside lower joint arm slots **352** of the drill bit coupling **350**.

In various embodiments, when a counter force is applied to the drill bit **308**, such as during drilling, the counter force pushes the drill bit **308** up and causes the joint hinges **326** to rotate inward as the joint arms **320** push outward. The joint arms **320** contact the inner wall (not shown) of the central drill shell **200** and form friction lock FL with the inner wall as described hereinabove in reference to FIG. **13** and FIG. **14**. Once the joint arms **320** contact the inner wall of the central drill shell **200**, the drill bit **308** stops moving upward and drilling is performed while pressure is maintained. When the central drill shell **200** rotates due to a driving force from a motor (described hereinabove in reference to the other figures), the joint arms **320** rotate with the central drill shell **200** due to friction lock FL, and as the joint arms **320** rotate, the drill bit coupling **350** and the drill bit **308** rotate. Once puncture occurs, the counter force is removed from the drill bit **308**, the joint arms **320** disengage friction lock FL, and the spring **304** (described hereinabove in reference to FIG. **13** and FIG. **14**), which includes three springs in FIG. **13** and FIG. **14** but may include one or more springs, withdraws the plunge protection harness **300** automatically. Thus, the drill bit **308** is pulled back away from the hole in the drilling surface (see, FIG. **13**). In some embodiments, the drill bit **308** is withdrawn out of the hole in the drilling surface (see, FIG. **13**) entirely. In other embodiments, the drill bit **308** is prevented from advancing further into the hole in the drilling surface (see, FIG. **13**).

In some embodiments, three joint arms **320** are included as illustrated in FIG. **15**. In other embodiments, four or five joint arms **320** are included. In still further embodiments, any number of joint arms **320** are included, such as only two or more than five. The joint arms **320** are illustrated with single members for the upper joint arm **322** and the lower joint arm **324** in accordance with an embodiment. In other embodiments, the lower joint arm **324** may include two members, one on each side of the upper joint arm **322** at the joint hinge **326**. In still other embodiments, the upper joint arm **322** may include two members, one on each side of the lower joint arm **324** at the joint hinge **326**. According to some embodiments, any type of hinge or joint may be used at the joint hinge **326**. According to some embodiments, any type of hinge or joint may be used at the joint shoulder hinge **314** or the coupling hinge **354**.

FIGS. **16**A and **16**B illustrate further embodiments for of the joint arms **320** for friction lock FL. As described in reference to FIG. **13**, the inner wall of the central drill shell **200** may include a rough surface, a high friction surface, a ribbed surface, or one or more ridges in various embodiments. In further embodiments, a mechanical connection is included between the central drill shell **200** and the joint arms **320**. The mechanical connection implements friction lock FL and provides further robustness of the lock during drilling where the mechanical connection is relied upon beyond a friction only based connection. FIGS. **16**A and **16**B illustrate zoom-in views of a joint arm **320** interface with the central drill shell **200** according to two example embodiments. As described in reference to the other figures, such as FIG. **15** above, there may be multiple joint arms **320**, but only a single joint arm **320** is illustrated in each of FIGS. **16**A and **16**B in the zoom-in views.

In FIG. **16**A, a mechanical connection **360** is between the joint arm **320** and the central drill shell **200**. In such embodiments, the upper joint arm **322** includes a joint hook **364** that catches on a ridge **362**A on the inside surface of central drill shell **200**. During drilling when the joint arms **320** are extended and in contact with the central drill shell **200**, as described further hereinabove in reference to the other figures (such as FIGS. **13**, **14**, and **15**), the joint hook **364** locks in place with the ridge **362**A to form mechanical connection **360**. In such embodiments, mechanical connection **360** implements friction lock FL and includes the mechanical connection in addition to the friction-based connection.

In various embodiments, the central drill shell **200** may include protrusion **362**B (shown in broken lines), such that protrusion **362**B and ridge **362**A form an indentation between them in central drill shell **200** where the joint hook **364** engages when the counter force is transferred into the joint arms **320** to cause them to expand, as described hereinabove in reference to the other figures (such as FIGS. **13**, **14**, and **15**). In some embodiments, there may be multiple of the ridges **362**A on the inside surface of central drill shell **200**, but FIG. **16**A illustrates only one of ridge **362**A for simplicity of illustration.

In FIG. **16**B, a mechanical connection **360** is between the joint arm **320** and the central drill shell **200** as similarly described in reference to mechanical connection **360** in FIG. **16**A. Mechanical connection **360** is formed by an angled joint hook **368** that catches on an angled indentation **366** in central drill shell **200**. In some embodiments, there may be multiple of the angled indentations **366** on the inside surface of central drill shell **200**, but FIG. **16**B illustrates only one of angled indentation **366** for simplicity of illustration.

In some alternative embodiments, the lower joint arm **324** may also include a disengaging bump **361**, which functions to push angled the joint hook **368** out of the angled indentation **366** once the counter force is removed and the lower joint arm **324** begins to rotate downward.

One element or feature included in various embodiments as contemplated here that is not illustrated in the figures is position tracking for further improved catheter placement accuracy. In a first version with position tracking, the guide-hub **110** and drilling structure **100** may integrate with an augmented reality system that will overlay the patient's brain scan and guide drilling or catheter placement. In such solutions, the guide-hub **110** may include markers or other indicia for use with the augmented reality system to calibrate and align the drilling and catheter insertion. The augmented reality system could also be implemented as a virtual reality system. In a second version with position tracking, the guide-hub **110** may include a position sensor system that calculates the position of the guide-hub **110** and the target position and alignment. The guide-hub **110** would include an indicator, such as an LED light or array, that indicates to the neurosurgeon when the guide-hub **110** is positioned correctly for drilling and catheter insertion. The position sensor system may include accelerometers or gyroscopes, infrared position tracking, EMF based triangulation, or other position tracking systems. In this solution, the position tracking and calculation could be done automatically without the neurosurgeon's interaction and the system could be used to indicate to the neurosurgeon the correct position of the guide-hub before drilling.

The various embodiments are described at a high level. It is envisioned that various embodiments would be combined in part or in whole for different embodiments. Further, various modifications, additions, or subtractions might be made within the scope of this disclosure as will be readily appreciated by those of skill in the art. The initial description is presented in reference to a procedure for placing EVDs, however other procedures for accessing the brain are contemplated and the solutions described herein are intended for use with additional procedures.

What is claimed is:

1. A method of using a medical tool comprising a cranial access drill, the method comprising:
placing a guide-hub against a cranial drilling surface, the guide-hub comprising an axial direction;
guiding a drill bit into the guide-hub along the axial direction;
drilling the cranial drilling surface in the axial direction with the drill bit using a motor;
detecting, using a controller, an electrical parametric change at the motor that corresponds to puncturing the cranial drilling surface, the electrical parametric change being a voltage change at the motor; and
deactivating, using the controller, the motor in response to detecting the electrical parametric change.

2. The method of claim **1**, wherein the electrical parametric change at the motor is a change in electrical properties of an electrical circuit comprises the drill bit, the cranial drilling surface, and the motor.

3. The method of claim **2**, wherein the controller is a microcontroller disposed in the cranial access drill and electrically coupled to the electrical circuit, and wherein detecting the electrical parametric change comprises detecting the change in electrical properties by the microcontroller.

4. The method of claim **1**, wherein the controller is a microcontroller disposed in a drill housing mechanically coupled to the drill bit, the microcontroller and the motor being electrically coupled to a battery, the motor and the battery also being disposed in the drill housing.

5. The method of claim **1**, wherein the drill bit has a conical tip.

6. The method of claim **5**, wherein the conical tip is a cutting tip.

7. The method of claim **1**, further comprising:
removing the drill bit from the guide-hub after deactivating the motor;
aligning a catheter guide into the guide-hub; and
inserting a catheter into the catheter guide and punctured cranial drilling surface.

8. The method of claim **7**, wherein the catheter guide is integrated into the guide-hub.

9. A method of using a drilling system, the method comprising:
placing a guide-hub on a drilling surface, the guide-hub comprising an axial direction;
guiding a drilling insert into the guide-hub along the axial direction, wherein the drilling insert comprises a drill bit and a harness;
drilling the drilling surface with the drill bit, wherein the axial direction of the guide-hub is parallel to a surface normal of the drilling surface during the drilling;
detecting, using the harness, when the drill bit punctures the drilling surface; and
automatically stopping the drilling in response to detecting that the drill bit has punctured the drilling surface, wherein the drilling surface is a cranial drilling surface,
wherein the drilling comprises drilling the cranial drilling surface by rotating the drilling insert within the guide-hub along with the drill bit, and
wherein the detecting comprises detecting, by the harness, when the drill bit punctures the cranial drilling surface to prevent further plunge using an electrical parametric change that corresponds to puncturing the cranial drilling surface or using an engaged friction lock of the harness that disengages automatically when the drill bit punctures the cranial drilling surface.

10. A method of using a cranial access drill, the method comprising:
drilling a cranial surface with a drill bit of the cranial access drill using a motor causing the drill bit to spin;
puncturing the cranial surface with the drill bit;
detecting, using a controller, an electrical parametric change in electrical properties of an electrical circuit resulting from a torque change at the motor that corresponds to puncturing the cranial surface; and
deactivating, using the controller, the motor to stop the drill bit from spinning in response to detecting the electrical parametric change.

11. The method of claim **10**, wherein detecting the electrical parametric change further comprises detecting the electrical parametric change at the drill bit.

12. The method of claim **10**, wherein detecting the electrical parametric change further comprises detecting the electrical parametric change at the motor.

13. The method of claim **10**, wherein the change in electrical properties comprises a voltage change at the motor.

14. The method of claim **13**, wherein the electrical circuit comprises the motor and the controller implemented as a microcontroller disposed in the cranial access drill.

15. The method of claim **13**, wherein the electrical circuit comprises the drill bit, the cranial drilling surface, and the motor.

16. The method of claim **10**, wherein the controller is a microcontroller disposed in the cranial access drill and electrically coupled to the electrical circuit, and wherein detecting the electrical parametric change comprises detecting the change in electrical properties by the microcontroller.

17. The method of claim **10**, wherein the electrical circuit comprises the drill bit, the cranial drilling surface, and the motor.

18. The method of claim **10**, wherein the controller is a microcontroller disposed in a same housing of the cranial access drill as the motor.

19. The method of claim **18**, wherein the microcontroller and the motor are electrically coupled to a battery, the battery also being disposed in the same housing as the motor.

20. The method of claim **10**, wherein the torque change at the motor is caused by a decrease in physical resistance to the spinning of the drill bit when the cranial surface is punctured.

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