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(54) **LASER CONTROL SYSTEM AND APPARATUS FOR DRILLING AND BORING OPERATIONS**

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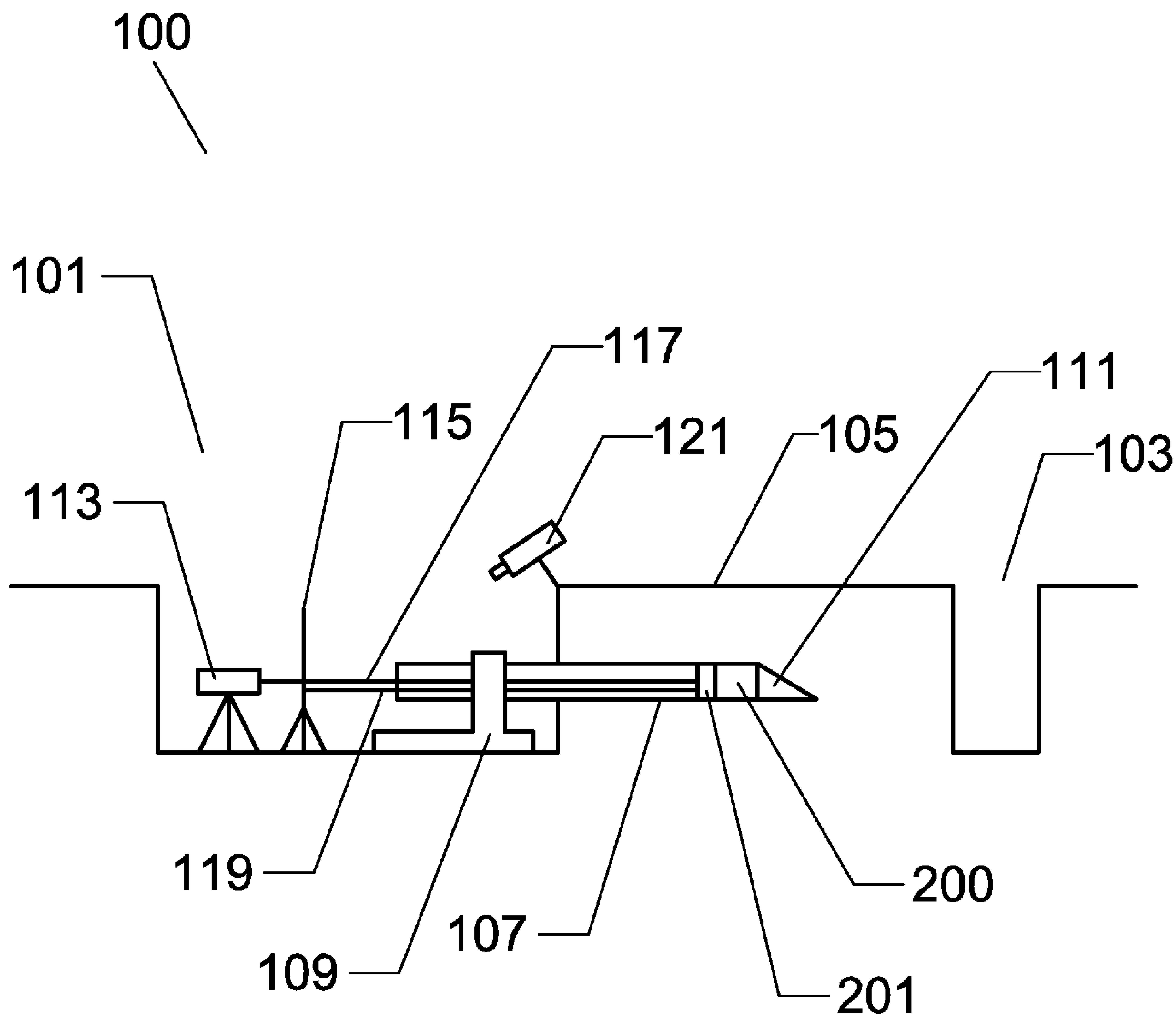
(57) **ABSTRACT**

A laser control system and apparatus for guiding a drilling or boring operation during a trenchless technology implementation. In most if not all trenchless technology applications, direction of the pipe or utility structure through the earth is of utmost importance. Proper directional guidance throughout the trenchless technology implementation ensures not only that the resulting utility infrastructure is placed properly, but also ensures that the trenchless technology operation does not hit or otherwise damage (such as through vibrations) existing utilities and other underground objects. The laser control system and apparatus of the present invention comprises a laser, a laser control head having a prism, an audible alignment indicator operatively coupled to the laser control head, and a target having a laser beam hole.



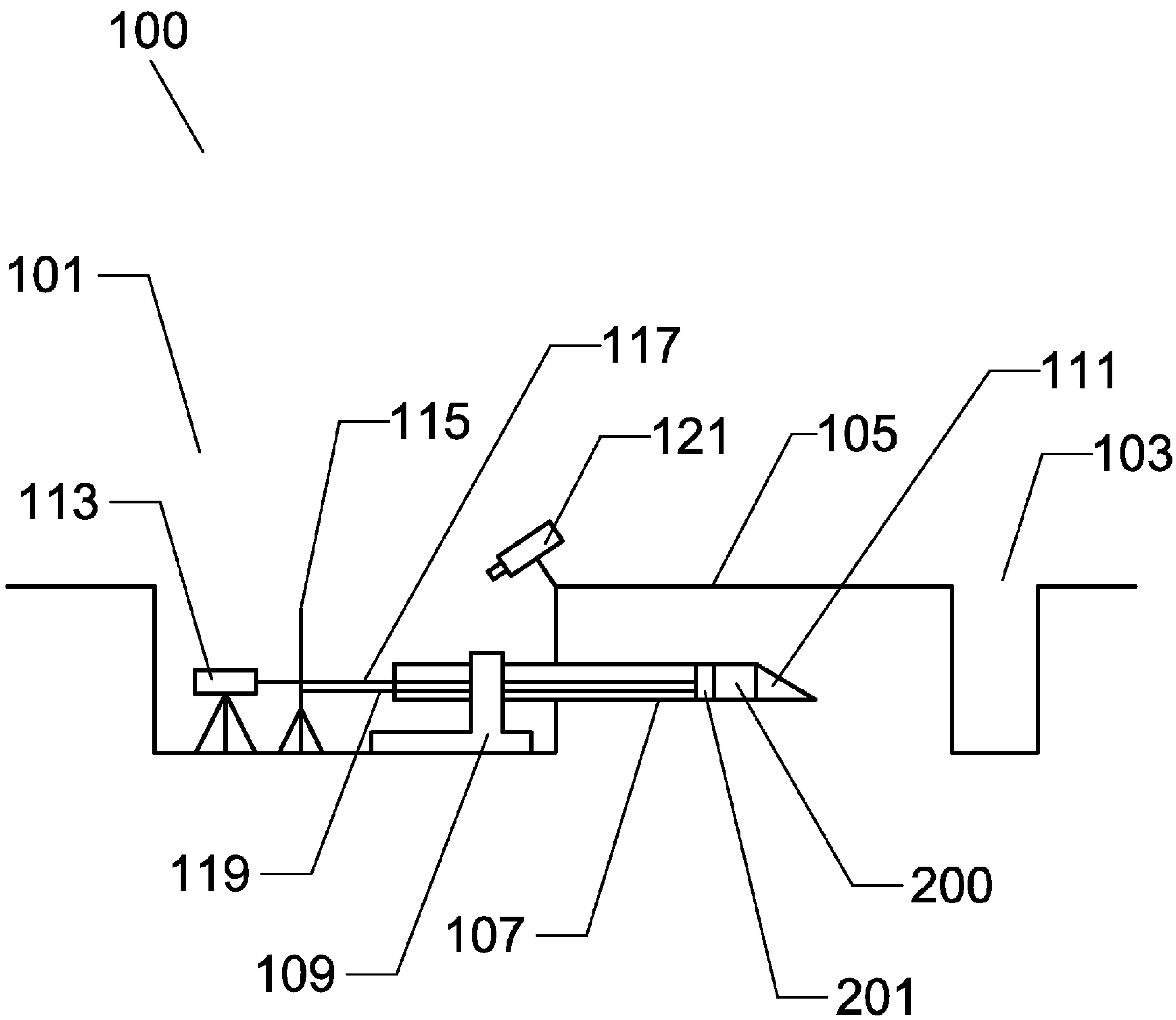


Fig. 1

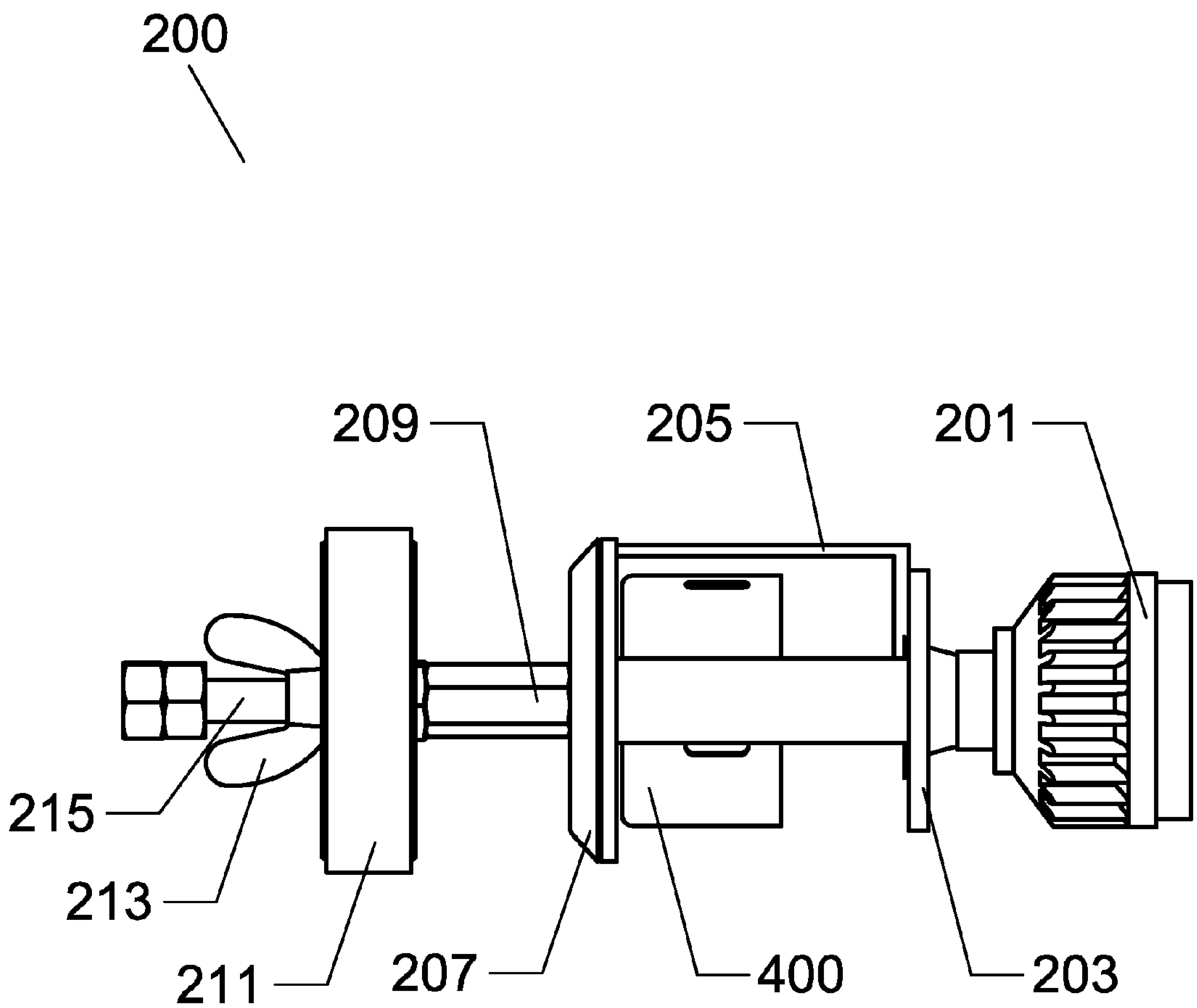


Fig. 2

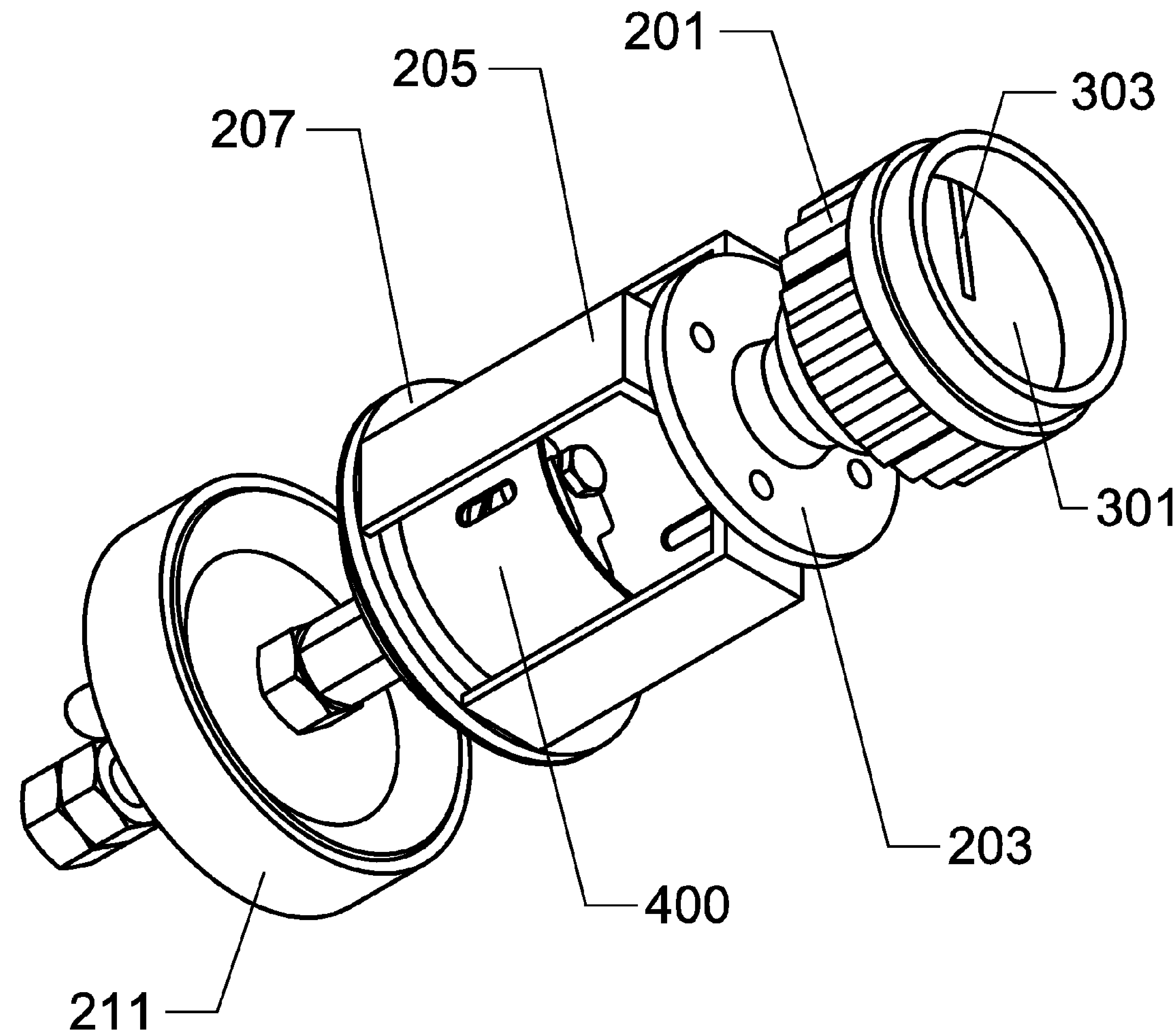


Fig. 3

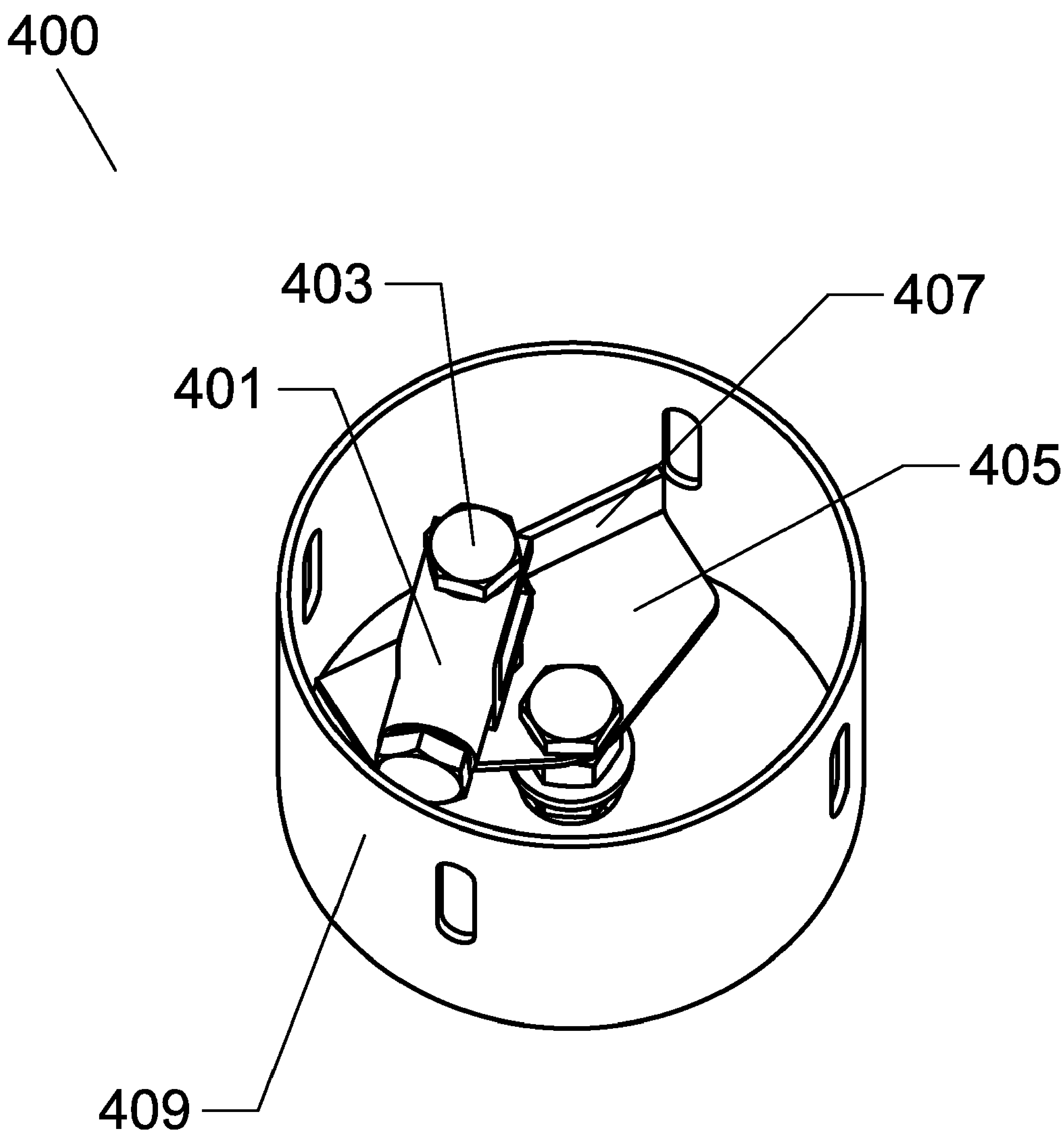


Fig. 4

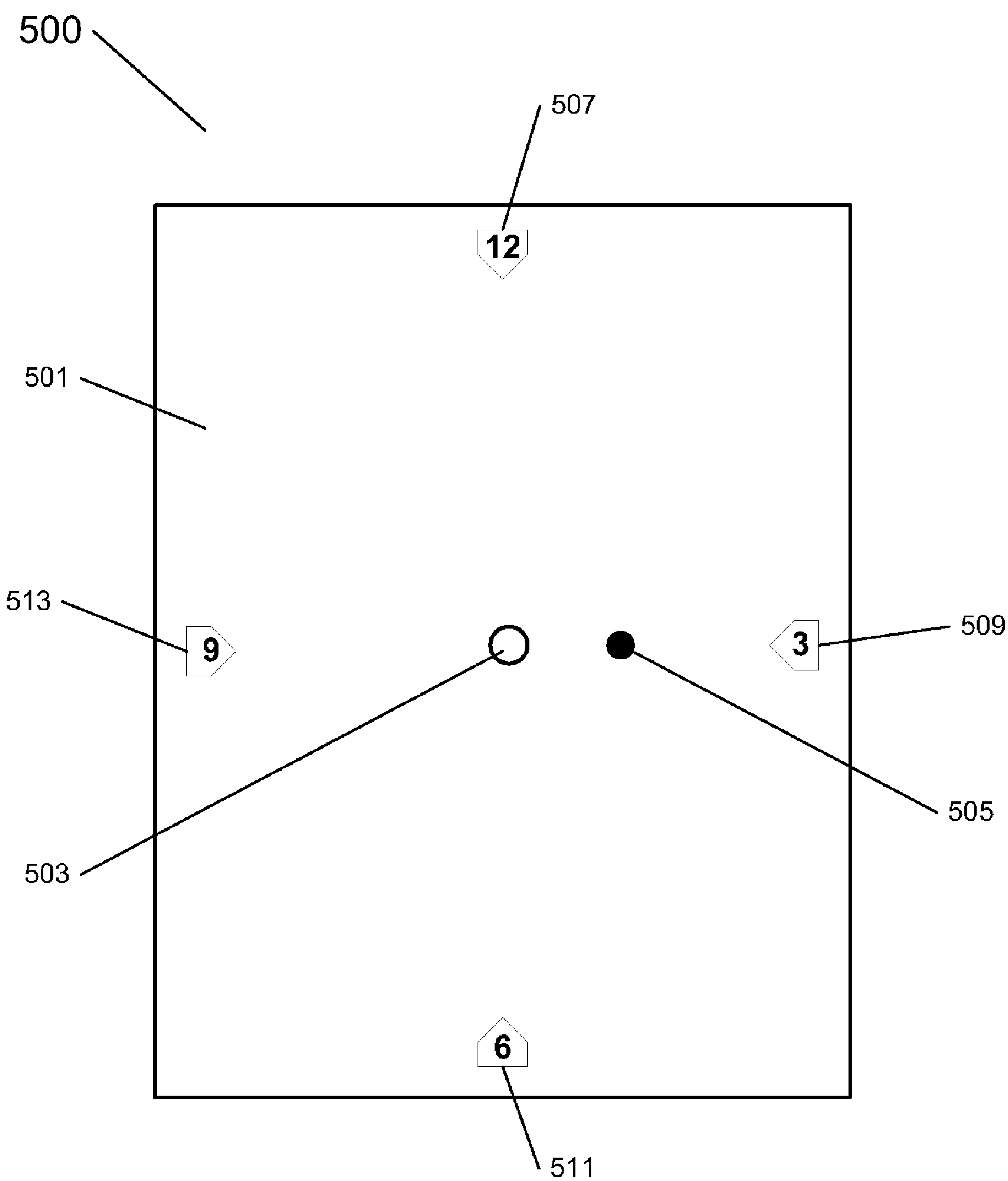


Fig. 5

LASER CONTROL SYSTEM AND APPARATUS FOR DRILLING AND BORING OPERATIONS

CROSS-REFERENCE TO RELATED PATENT APPLICATIONS

[0001] This application claims the benefit of the filing date of U.S. provisional patent application Ser. No. 60/827,116 filed on Sep. 27, 2006.

BACKGROUND OF THE INVENTION

[0002] 1. Field of the Invention

[0003] This invention relates generally to control systems for drilling and boring operations, and more particularly to a laser based control system and apparatus for drilling and boring operations.

[0004] 2. Description of Related Art

[0005] Trenchless technology is a growing field that includes a wide variety of methods and techniques for installing and rehabilitating underground infrastructure with minimal surface disruption and without the destruction and subsequent rebuilding of essential infrastructure that is common with trenching and excavation. Examples of trenchless technologies include, but are not limited to, microtunneling, pipejacking, pipe ramming, sliplining, guided boring, haul systems, tunnel boring, and earth pressure balance systems.

[0006] In most if not all trenchless technology applications, direction of the pipe or utility structure through the earth is of utmost importance. Proper directional guidance throughout the trenchless technology implementation ensures not only that the resulting utility infrastructure is placed properly, but also ensures that the trenchless technology operation does not hit or otherwise damage (such as through vibrations) existing utilities and other underground objects.

[0007] In some trenchless technology operations such as microtunneling and guided boring, the boring or tunneling tool can be guided during the operation itself by various techniques. In other trenchless technology operations, such as pipejacking and pipe ramming, the method is non-steerable, and pipes installed by these methods are laid straight. Often times a pilot tube is placed prior to the pipejacking or pipe ramming operation using a technique such as microtunneling. The subsequent pipejacking or pipe ramming operation will then follow the pilot tube to ensure that the pipe is installed in it's proper location.

[0008] In guiding a trenchless technology operation, knowledge of when the cutting head is deviating from it's intended course is extremely valuable so that the machine operator can make adjustments necessary to bring the direction of the cutting head back on course. The cutting head may deviate from it's intended course for a variety of reasons, such as machine or operator inputs, encounter of different soil types, encounter of a rock or boulder, and the like. Knowing when such a deviation occurs and the extent of such a deviation is important to ensure that timely course corrections are made.

[0009] It is an object of the present invention to provide a laser control system and apparatus for drilling and boring operations. It is another object of the present invention to provide a laser control system and apparatus for drilling and boring operations where the control head is low cost in the event of a cutting head malfunction. It is a further object of the present invention to provide a laser control system and apparatus for drilling and boring operations where the control head does not require a power source. It is a further object of the present invention to provide a laser control system and apparatus for drilling and boring operations that is reliable and not susceptible to failure. It is a further object of the present invention to provide a laser control system and apparatus for drilling and boring operations that can optionally be operated remotely.

BRIEF SUMMARY OF THE INVENTION

[0010] In accordance with the present invention, there is provided a laser control system and apparatus for drilling and boring operations comprising a laser, an optical control head, an audible alignment indicator operatively coupled to the optical control head, and a target having a laser beam hole.

[0011] The foregoing paragraph has been provided by way of introduction, and is not intended to limit the scope of the present invention as defined by this specification, drawings, and attached claims.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012] The invention will be described by reference to the following drawings, in which like numerals refer to like elements, and in which:

[0013] FIG. **1** is a diagram of a laser controlled trenchless operation;

[0014] FIG. **2** is a plan view of an optical control head;

[0015] FIG. **3** is a perspective view of an optical control head;

[0016] FIG. **4** is a perspective view of an audible alignment indicator; and

[0017] FIG. **5** is a plan view of a target.

[0018] The present invention will be described in connection with a preferred embodiment, however, it will be understood that there is no intent to limit the invention to the embodiment described. On the contrary, the intent is to cover all alternatives, modifications, and equivalents as may be included within the spirit and scope of the invention as defined by this specification, drawings, and appended claims.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0019] For a general understanding of the present invention, reference is made to the drawings. In the drawings, like reference numerals have been used throughout to designate identical elements.

[0020] FIG. **1** is a diagram of a laser controlled trenchless operation. In a horizontal trenchless operation, it is common to have an insertion pit **101** and a receiving pit **103** that correspond with the origination and the termination of the trenchless operation or a segment thereof. The insertion pit **101** and the receiving pit **103** are typically excavated and often times reinforced for worker safety. If the trenchless operation is performed on a slope, one or both of the insertion pit **101** and the receiving pit **103** may not be necessary. An example of such an application is the trenchless installation of a culvert pipe under a raised railroad bed where trenchless technology is used to prevent settling or disruption of the railroad bed. The raised railroad bed has slopes on either side of the railroad bed that negate the need to excavate an insertion pit **101** or a receiving pit **103**. FIG.

1 further shows the top of terrain **105**. The laser controlled trenchless operation of FIG. **1** is exemplary only, and is not intended to limit the scope of the present invention to any particular type or method of trenchless technology. A pipe **107** is drilled from the insertion pit **101** to the receiving pit **103**. The pipe **107** may be steel or other material suitable to drilling or boring operations, as will be known to those skilled in the art. The pipe **107** may be rotated and driven by a drive unit **109**. Examples of such drive units are those units manufactured by Akkerman, Inc. of Brownsdale, Minn., and whose products can be seen at www.ackermnanin.com. The drive unit **109** provides rotation to the pipe **107** as well as horizontal displacement sufficient to progress the drilling or boring operation. At the far end of the pipe **107** is a pipe head **111** that serves to cut through soil as the pipe **107** is rotated and driven by the drive unit **109**. In some embodiments of the present invention, tile pipe head **111** is beveled to help guide placement of the pipe **107**. An operator can control the yaw and pitch of the pipe **107** as it is being inserted through the ground. This control is performed by slowing or stopping the rotation of the pipe **107** at the drive unit **109** while maintaining or modifying the horizontal force applied to the pipe **107**. Due to the geometry of the pipe head **111**, the pipe **107** will tend to track on a linear course when rotation is applied from the drive unit **109**, and will tend to track in a non-linear fashion when rotation from the drive unit is slowed down or stopped. This attribute is useful in controlling the direction of the pipe **107**. Should the pipe **107** deviate from it's intended course during installation, the direction of the pipe **107** can be altered by slowing or stopping the rotation of the pipe **107**, orienting the pipe head **111** such that the beveled surface of the pipe head provides non-linear tracking in the intended direction, and then resuming rotation of the pipe **107** once it is determined that the pipe **107** has returned to it's intended course during installation. The laser control system and apparatus of the present invention allows one to determine if the direction of travel of the pipe **107** has deviated from it's intended course during installation, and further, allows one to determine the angular position of the pipe head **111** such that course corrections can be made. The laser control system and apparatus of the present invention uses an optical control head **200** with a prism **201** within the pipe **107** to provide information to an operator regarding the direction of travel of a pipe **107** being installed and the angular position of the pipe head **111**. A laser **113** originates a sending beam **117** through a hole in a target **115**, through the drive unit **109**, and down the length of pipe **107**. Upon reaching the prism **201**, a returning beam **119** travels down the length of pipe **107** until it strikes a target **115**. The prism **201** may be any prism used to redirect light, and in particular laser light. The return beam **119** is oriented with respect to the sending beam **117** based on the angular position of the prism **201** and the attached optical control head **200**. It is thus important to know the angular position of the prism **201** and the attached optical control head **200** during the boring s or drilling operation. The target **115** is shown in further detail in FIG. **5**, and provides the location of the sending beam **117** by way of a pass through hole and the returning beam **119**. The placement of the sending beam **117** with respect to the returning beam **119** provides the operator with information on the deviation of travel of the pipe **107** during installation. This allows the operator to make minor course corrections throughout the installation process. It is important to know the angular position of the optical control head **200** so that the pipe head **111** can be rotated to the proper position to allow for travel in a specified direction. The optical control head **200** contains a signaling mechanism that allows for the determination of angular position of the control head **200**. This mechanism will be shown in FIGS. **2**, **3**, and **4**.

[0021] It is often times inconvenient or impossible to view the target **115** while operating the drive unit **109**. In these situations, an optional video camera **121** is directed at the target **115** and a display unit (not shown) may be placed in a position convenient for the operator or others to view the target **115**.

[0022] During operation of the laser control system and apparatus of the present invention, the target **115** is continuously monitored during a drilling or boring operation, and minor course deviations are corrected through operator intervention by slowing or stopping the rotation of the pipe **107**, orienting the pipe **107** and attached pipe head **111** in an angular position that will allow the pipe head **111** to travel in a direction that will compensate for the detected course deviation, providing horizontal displacement of the pipe **107** and pipe head **111** until such time as the course is corrected, and then returning to rotational and horizontal displacement boring or drilling.

[0023] As will become evident to one skilled in the art after reading this specification with the attached drawings and claims, the laser control system and apparatus of the present invention is well suited to a variety of trenchless operations, and also to vertical boring and drilling operations.

[0024] Turning now to FIG. **2**, a plan view of an optical control head according to one embodiment of the present invention is shown. The prism **201**, as previously described, can be seen. The prism **201** is structurally attached to a first flange **203**, which is in turn connected to a strut **205** that is in turn connected to a second flange **207**. The purpose of the flange and strut arrangement is to provide mechanical integrity to the device and also to provide acoustical isolation for the audible alignment indicator **400**. In some embodiments of the present invention, the audible alignment indicator may be electronic, using a position sensing device such as a mercury switch and an electronic device such as a buzzer, horn, bell, or the like. The first flange **203**, the strut **205**, and the second flange **207** may be made from a metal such as steel, brass, copper, stainless steel, or the like. The first flange **203**, the strut **205**, and the second flange **207** may also be made from a plastic. The audible alignment indicator **400** is shown in further detail in FIG. **4**, and essentially provides an audible signal similar to a bell when the optical control head **200** is placed at an angular position that would indicate 12 o'clock, or another fixed reference point. The audible alignment indicator **400** may be made from a metal such as steel, brass, copper, stainless steel, or the like. A shaft **209** connects the second flange **207** to an expandable plug **211**, a tightener **213** and a threaded shaft **215**. The shaft **209**, the tightener **213** and the threaded shaft **215** may be made from a metal such as steel, brass, copper, stainless steel, or the like. The shaft **209**, the tightener **213** and the threaded shaft **215** may also be made from a plastic. The expandable plug **21** may be made from a material such as rubber, silicone, or the like. The purpose of the expandable plug **211**, tightener **213** and threaded shaft **215** is to attach the optical control head **200** to the inside of a pipe without allowing for rotation. While the expandable plug **211**, tightener **213** and threaded shaft **215** portray a specific embodiment, other attachment means may be used without departing from the spirit and scope of the present invention.

[0025] Turning now to FIG. **3**, a perspective view of an optical control head according to one embodiment of the present invention is shown. The prism assembly **201** can be seen along with the prism glass **301** and a visual alignment indicator **303**. The visual alignment indicator **303**, as can be seen in FIG. **3**, is a marking that indicates 12 o'clock or another fixed angular position reference. Also shown in FIG. **3** is the first flange **203**, the strut **205**, and the second flange **207**. Also shown is the audible alignment indicator **400**.

[0026] Turning now to FIG. **4**, a perspective view of an audible alignment indicator **400** according to one embodiment of the present invention is shown. The audible alignment indicator **400** has been removed from the optical control head **200** for clarity, and serves to provide an audible indication of a specified angular position. As can be seen in FIG. **4**, a striker **401** is attached to a pivot pin **403** and is free to rotate about the pivot pin **403** upon rotation of the audible alignment indicator **400**. The pivot pin **403** is offset from the center of the bell housing **409** such that the striker **401** clears the bell housing **409** when rotated 180 degrees, and strikes the bell housing only when rotated a full 360 degrees. This allows for an audible indication only once in a complete 360 degree rotation and also provides the cam-like displacement required for proper operation of the striker **401**. In addition, a striker guide plate **405** contains a stop **407** that retains the striker **401** through 90 degrees of rotation and then releases the striker **401** past 90 degrees of rotation such that the striker **401** strikes the bell housing **409** and generates a bell like sound. The components of the audible alignment indicator **400** are preferably a metal such as steel, brass, copper, stainless steel or the like. Plastic materials may also be used for some of the components.

[0027] Lastly, FIG. **5** shows a plan view of a target **500** according to one embodiment of the present invention. The target backing **501** may be made of paper, plastic, spunbonded polyolefin wood, steel, aluminum, or any material that is suitable for a planar structure. A laser beam hole **503** is placed through the target **500** to accommodate a sending laser beam as was previously described and portrayed by way of FIG. **1**. A laser beam termination **505** may be seen on a target in use. The target further may have angular displacement markings such as the clock indicators **507** to represent 12 o'clock, **509** to represent 3 o'clock, **511** to represent 6 o'clock, and **513** to represent 9 o'clock. Alternatively, other angular displacement indicators in degrees, radians, or the like, may also be used. The position of the laser beam termination **505** in relation to the laser beam hole **503** indicates the deviation distance and direction from course during a boring or drilling operation. The target **500** may also contain a laser sensing device or devices such as an infrared sensor, photo diode, or the like. Further details related to the use of the target **500** with the laser control system and apparatus of the present invention have been previously provided in this specification.

[0028] It is, therefore, apparent that there has been provided, in accordance with the various objects of the present invention, a laser control system and apparatus for drilling and boring operations. While the various objects of this invention have been described in conjunction with preferred embodiments thereof, it is evident that many alternatives, modifications, and variations will be apparent to those skilled in the art. Accordingly, it is intended to embrace all such alternatives, modifications and variations that fall within the spirit and broad scope of this specification, drawings, and appended claims.

What is claimed is:

1. An optical control head for drilling and boring operations comprising:

a prism assembly having a prism, the prism assembly being connected to a shaft;

a first flange operatively coupled to said shaft;

an audible alignment indicator operatively coupled to said shaft; and

a second flange operatively coupled to said shaft.

2. The optical control head as recited in claim **1**, further comprising an expandable plug connected to said shall.

3. The optical control head as recited in claim **1**, further comprising a tightener connected to said shaft.

4. The optical control head as recited in claim **1**, wherein said audible alignment indicator comprises a bell housing and a striker.

5. The optical control head as recited in claim **1**, wherein said audible alignment indicator comprises a bell housing, a striker, a pivot pin and a stop.

6. The optical control head as recited in claim **1**, wherein said audible alignment indicator is electronic.

7. The optical control head as recited in claim **1**, further comprising a strut connected to said first flange and said second flange.

8. The optical control head as recited in claim **1**, wherein said prism has a visual alignment indicator marking.

9. A target for drilling and boring operations comprising:

a target backing;

a laser beam hole made in the target backing; and

angular displacement markings made on the target backing.

10. The target for drilling and boring operations as recited in claim **9** further comprising a laser beam termination.

11. The target for drilling and boring operations as recited in claim **9**, wherein said angular displacement markings are clock indicators.

12. The target for drilling and boring operations as recited in claim **9**, wherein said angular displacement markings are in degrees.

13. Tile target for drilling and boring operations as recited in claim **9**, wherein said angular displacement markings are in radians.

14. The target for drilling and boring operations as recited in claim **9** further comprising a laser beam sensor.

15. A laser control system for drilling and boring operations comprising:

a laser;

an optical control heady;

an audible alignment indicator operatively coupled to the optical control head;

and a target having a laser beam hole.

16. The laser control system for drilling and boring operations as recited in claim **15**, further comprising a pipe operatively coupled to said optical control head.

17. The laser control system for drilling and boring operations as recited in claim **15**, is further comprising a prism operatively coupled to said optical control head.

18. The laser control system for drilling and boring operations as recited in claim **17**, wherein said prism has a visual alignment indicator marking.

19. The laser control system for drilling and boring operations as recited in claim **15**, wherein said audible alignment indicator is mechanical.

20. The laser control system for drilling and boring operations as recited in claim **15**, wherein said audible alignment indicator is electronic.

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