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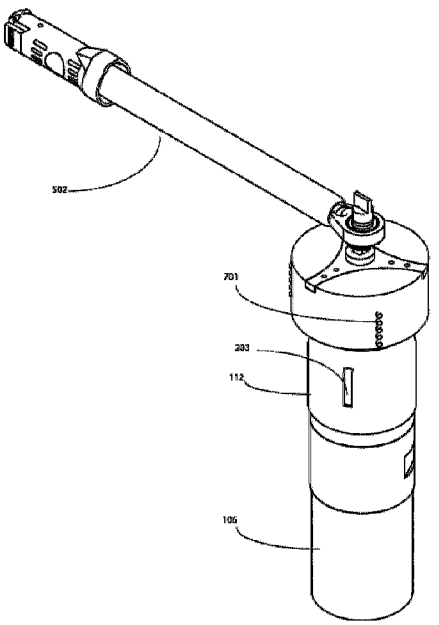
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(71) Demandeur/Applicant:
MACDONALD, JAMUS, US

(72) Inventeur/Inventor:
MACDONALD, JAMUS, US

(74) Agent: ATHANASSIADIS, ARIADNI

(54) Titre : SYSTEME D'INTERFACE DE SABOT ERGONOMIQUE POUR LE CAROTTAGE
(54) Title: ERGONOMIC SHOE INTERFACE SYSTEM FOR CORE DRILLING



(57) Abrégé/Abstract:
A shoe interface system and related methods are provided, where the shoe has a threaded connection to another tubular component of an inner tube assembly used in earth core drilling systems. The shoe interface system comprises a shoe and a tool used to connect and disconnect the shoe from said other tubular component by way of applying a complementary coupling interface that contributes to, or enhances the overall coupling pattern used to create sufficient engagement between contacting surfaces of the shoe and tool, and thus enable the connection and disconnection of the shoe when the tool is in use to break or create a friction lock at the threaded connection. Each complementary coupling interface comprises one or more pairings of raised and depressed surfaces that can be aligned and fitted with one another as a means to make the operation of the tool more ergonomic for the user.

ABSTRACT

A shoe interface system and related methods are provided, where the shoe has a threaded connection to another tubular component of an inner tube assembly used in earth core drilling systems. The shoe interface system comprises a shoe and a tool used to connect and disconnect the shoe from said other tubular component by way of applying a complementary coupling interface that contributes to, or enhances the overall coupling pattern used to create sufficient engagement between contacting surfaces of the shoe and tool, and thus enable the connection and disconnection of the shoe when the tool is in use to break or create a friction lock at the threaded connection. Each complementary coupling interface comprises one or more pairings of raised and depressed surfaces that can be aligned and fitted with one another as a means to make the operation of the tool more ergonomic for the user.

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ERGONOMIC SHOE INTERFACE SYSTEM FOR CORE DRILLING

FIELD OF THE INVENTION

[0001] The present invention relates to the field of resource exploration core drilling systems leveraged to locate natural resources by creating retrievable cores of earth that may be accessed and checked for the presence of the desired resources in the field, pertaining particularly to an ergonomic inner tube shoe interface system for unthreading the shoe from cylindrical core drilling components, and rethreading the shoe back onto cylindrical core drilling components, and a method including a tool for breaking the shoe's threaded connection, as well as for restoring the shoe's threaded connection.

BACKGROUND OF THE INVENTION

[0002] Within the field of earth exploration for natural resources, scientists and prospectors often require physical core samples to be extracted from the earth using core drilling equipment. Typical core drilling systems employ a rotating open-ended core bit rigidly joined to a pipe called a core barrel. In general practice, the rotating bit cuts a cylindrical elongated core sample of earth aided by downward penetration force through a drill string and fluid discharge. A stationary center core resulting from the drilling process may be retrieved by a latchable inner tube pipe latched to a wire line, the pipe sliding down around the cylindrical core.

[0003] The far end of the core capturing inner tube is referenced in the art as a shoe, typically a combination of one or more relatively heavy pipe components threaded together and amongst hosted core retention mechanisms. The primary function of the shoe is to hold core breaking and retaining mechanisms. A shoe assembly refers to one or more annular components, typically a lower shoe and upper shoe threaded together which encase core retaining mechanisms. The lower shoe of the shoe assembly is slightly larger in diameter than the upper shoe. The lower shoe hosting the core breaking mechanism and the upper shoe component of the shoe assembly hosting the core holding or retaining mechanism which are referred to as basket catchers but not limited to basket catchers per se. Typically the lower shoe is fastened to an upper shoe by a threaded connection, which aids in assembly, and manufacturing time to machine seats, flanges, and mounts which hold and position basket catchers, core breakers, and other core breaking/retaining mechanisms. However, some systems use a single

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annular body shoe assembly, utilizing spacers or flanges to hold the core breakers, and potentially basket catchers and/or other core breaking or retaining mechanisms dependent on the type of earth formation being cored. For example, in loose sand, some systems may close completely around the core sample bottom after separation of the sample from the earth. In some embodiments, there could be a middle shoe or multiple shoe segments which also hold different core breaking or retention mechanisms.

[0004] The inside of the shoe assembly may serve multiple functions including holding and positioning core breakers and holding basket catchers. The lower shoe on its outside may function as a pressure nozzle for fluid from a pump to both lubricate the core bit of the core barrel, and, in one embodiment help remove earth cuttings with hydraulic pressure. Hydraulic pressure which discharges within the core bit, and around the outside of the lower shoe can act partially as the core cutting mechanism cutting core from the earth with hydraulic pressure. This may be somewhat dependent on the specific earth formation being core drilled.

[0005] An adjustable lead screw mechanism facilitates the vertical distance between the lower shoe and the core bit for user control of the hydraulic pressure at the bit. The shoe assembly has at least a lower shoe, but in practice typically contains two parts, generally the upper and lower shoe portions as described above. The upper shoe portion holds annular/radially aligned biased springs known in the art as basket catchers, the lower shoe portion typically holds and positions the movement of the core spring breakers on their interior diameters. The lower shoe portion has an outside diameter larger than the upper shoe portion or the inner tube to help stabilize the inner tube pipe assembly. Middle shoes can be employed to hold other core breaking and retaining mechanisms, although this is not typical. The shoe portions may be connected together along with at least one core retention mechanism to form the shoe assembly. A step down function on the free end of the lower shoe component of the shoe assembly functions to focus pressurized fluid discharge.

[0006] The inner tube pipe is typically suspended on a bearing apparatus that hangs within the larger diameter core barrel. The core bit at the end of the core barrel typically includes an internal polygonal inside-diameter structure, the vertices thereof enabling fluid to pass around the shoe assembly to the core bit. The flats of the polygonal feature or other geometric form coupled with the larger inside diameter of the lower shoe

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function to keep the inner tube assembly from tilting or yawing. An inner tube assembly is retrieved with a core sample inside and is then laid horizontally such as on a workbench where a worker or workers proceed to disassemble the inner tube assembly to extract the captured core sample.

[0007] A challenge with this process is the difficulty relative to breaking the threaded connection that the shoe has with the inner tube pipe. During exploration drilling, many inner tube assemblies containing core samples up to about three meters or more in length are retrieved and stacked for disassembly, core extraction, and reassembly. Six and nine meter length inner tube pipes within the inner tube assembly are not unheard of. Typical workflow per bench line worker or pair of workers may be to extract about 20 to 80 sample cores per day, with one worker typically threading and rethreading the shoe about 40 to 160 times a day, sometimes under harsh on-site conditions such as extreme cold or hot weather, humidity, dirt, mud, and/or tar-saturated environments. Workers may endure 12 hour shifts consecutively for up to 26 days.

[0008] Typically core breakers are housed in the lower shoe due to their durability, and proximity to the bit, and thereby the lowest extent of a drilled center core. The core breakers are an open-sided conical spring steel piece with a smooth exterior and a barbed interior. As the drill string moves relatively upward, the core breakers slide down the tapered housing hosted on the inside surface of the lower shoe and contract to grip, and ultimately break the core from the earth. The purpose of the core breakers, and all core retaining mechanisms, is to couple/lock the core to the shoe. Depending on the earth formation the core breakers may require significant force to break the core, and can become wedged and frictionally locked into the lower shoe. The unexpected, or unplanned for, result of utilizing core breakers to break the core from the earth, is that workers must also break the friction connection between the core breakers and the lower shoe when disassembling the shoe, or otherwise spin the shoe and the core many times to remove the shoe. In some cases, the core weighs up to about 100 pounds in rock formations. A worker may also be required to manually spin the core sample which is friction locked to the core breakers, and thereby the shoe.

[0009] In addition to the challenges of increased friction for shoe disassembly, the position of the workpiece and movements, including stance required by the bench workers in removing shoe assemblies from the inner tube pipes can be awkward for the worker

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and can cause strain or injury. Core drilling rigs generally use mobile workstations which are transported by helicopters, transfer trucks, or tracked vehicles, and therefore are confined to a small and quickly assembled workspace. The unintended consequence of designing confined work space is that the vice which holds the inner tube stationary may be positioned against a wall, on top of a bench, or against a railing, which may obstruct full rotation of a pipe wrench. Additionally, rig design is expensive and generally cannot be modified in the field. Once the thread lock is broken using a conventional pipe wrench, workers unthread the shoe assembly manually and may need to bend their wrists, or position their bodies in an awkward stance to manually unthread the shoe.

[0010] Many bench workers develop minor to severe carpal tunnel syndrome, tendonitis, and crepitus, often interrupting sleep patterns, causing pain or discomfort requiring medication and eventually corrective surgery. As carpal tunnel syndrome, tendonitis, and crepitus are generally less visible negative safety outcomes on core drilling job-sites, and only appear after hundreds, or thousands of repetitions of moving a load (generally with the wrist bearing the load), the extent of repetitive stress from removing a shoe from an inner tube pipe may not be obvious to safety managers, core drilling company owners, or rig tool design engineers.

[0011] With reference to the following overview of prior art, there is currently no system of coupling or decoupling a shoe which utilizes a complementary coupling system between the shoe and a wrench.

[0012] US Patent Document No. 20140290444A1 discloses a wrench having particular application in the core drilling industry which utilizes a collection of moveable pivotally affixed jaws which respectively contain regions of frictional gripping material which securely engage a core drilling shoe within a core drilling inner tube assembly, and assist a worker to leverage force to break the friction lock between cylindrical components inherent to a core drilling inner tube assembly to retrieve a sample. Due to high tolerances required within core barrel assemblies of earth core drilling systems, the wrench provides an improved gripping surface compared to standard pipe wrenches, which may mar, deform, scratch, and distort the cylindrical components of inner tube assemblies. The wrench also serves as an improvement in gripping the cylindrical inner tube components which may prevent injuries from the wrenches slipping while under considerable manual leveraged force to break the thread (friction) lock between cylindrical components.

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[0013] As can be appreciated from the prior art overviewed above, while the frictional gripping application of the object assists a worker's tasks, and minimizes damage to cylindrical components of inner tube assemblies, it does not reduce the prominent risk of strain or injury to the worker from repetitive motion and awkward stances.

[0014] Therefore, what is clearly needed is an ergonomically operable shoe interface for shoe disassembly and assembly within a core drilling system and a tool that facilitates ergonomic removal and replacement of the shoe in a production line.

SUMMARY OF THE INVENTION

[0015] It is an object of the present disclosure to describe systems, their components and related methods for ergonomically carrying out aspects of core drilling using an inner tube assembly. More particularly, a shoe interface system is described and related methods whereby complementary points of engagement between a first tubular body (namely a shoe of a shoe assembly) and a tool for connecting and disconnecting the first tubular body from a second tubular body of the inner tube assembly. These complementary points of engagement can be arranged so as to enhance the secure engagement between the first tubular body and tool and thereby facilitate use of the tool by a user to carry out the connecting and disconnecting of the first tubular body from the second tubular body of an inner tube assembly as required in the execution of a core drilling process. The complementary points of engagement are generally designed to be pairings of indentations and protrusions, between the first tubular body (shoe) and tool, or vice versa. The pairings of indentations and protrusions when aligned and fitted together contribute to the totality of physical engagement features between the shoe and tool (coupling pattern) to enable the application of and translation of a rotational force from the tool to the first tubular body. This results in either connection or disconnection of the first tubular body from the second tubular body via a threaded connection means, as generally used to assemble and disassemble tubular components of the inner tube assembly.

[0016] In one aspect, there is provided a shoe interface system comprising:

> a shoe, the shoe having an annular form, with an open first end and an open second end, the ends being joined by an annular wall with an outer surface and an inner surface, at least one of said ends having a threaded connection means for connecting to and disconnecting from a tubular body of an inner tube

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assembly; and

a friction breaking tool comprising a handle connected at one end to an annular or semi-annular structure, the structure having a contacting surface that fits over, or around a portion of the outer surface of the shoe's annular wall,

wherein the portion of the outer surface of the shoe and the contacting surface of the friction breaking tool's structure each comprise one or more coupling surfaces that can be aligned with each other when said structure is fitted over or around the portion of the outer surface of said shoe to form a complementary coupling interface, thereby providing a coupling pattern to facilitate a transfer of a rotational force when the friction breaking tool is operated by a user to connect or disconnect the threaded connection means of the shoe to or from the tubular body of the inner tube assembly.

[0017] In another aspect there is provided a shoe for constructing a shoe interface system, the shoe having an annular form, with an open first end and an open second end, the ends being joined by an annular wall with an outer surface and an inner surface, at least one of said ends having a threaded connection means for connecting to and disconnecting from a tubular body of an inner tube assembly; and wherein the outer surface of the shoe has one or more coupling surfaces comprising indentations or protrusions which can be aligned with complementary protrusions, or indentations of a friction breaking tool to facilitate the connection and disconnection of the shoe from the tubular body of the inner tube assembly when the friction breaking tool is operated by a user.

[0018] In still another aspect there is provided a method of forming a shoe interface for use in core drilling using an inner tube assembly, the method comprising the steps of:

providing a shoe having an annular form, with an open first end and an open second end, the ends being joined by an annular wall with an outer surface and an inner surface, at least one of said ends having a threaded connection means for connecting to and disconnecting from a tubular body of an inner tube assembly; and

connecting a friction breaking tool to the shoe, the friction breaking tool comprising a handle connected at one end to an annular or semi-annular structure, the structure having a contacting surface that fits over, or around a portion of the outer surface of the shoe's annular wall;

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wherein the portion of the outer surface of the shoe and the contacting surface of the friction breaking tool's structure each comprise one or more coupling surfaces that can be aligned with each other when said structure is fitted over or around the portion of the outer surface of said shoe to form a complementary coupling interface, thereby providing a coupling pattern to facilitate a transfer of a rotational force when the friction breaking tool is operated by a user to connect or disconnect the threaded connection means of the shoe to or from the tubular body of the inner tube assembly.

[0019] In one embodiment, the complementary coupling interface comprises one or more pairings of coupling surfaces, wherein each pairing consists of an indentation and a protrusion that fits into said indentation when aligned with each other.

[0020] In another embodiment, the one or more coupling surfaces of the outer surface of the shoe are indentations and the one or more coupling surfaces of the contacting surface of the structure of the friction breaking tool are protrusions.

[0021] In still another embodiment there are one or more indentations and said indentations are positioned equidistant from one another around the outer surface of the shoe.

[0022] In yet a further embodiment, the indentation is a slot oriented along a longitudinal axis of the shoe between the first and second ends of the shoe, or a seat disposed orthogonally to the longitudinal axis of the shoe.

[0023] In a further embodiment, the structure of the friction breaking tool has been machined to provide the protrusion, or is an object inserted through the contacting surface of the structure of the friction breaking tool.

[0024] In yet another embodiment, the friction breaking tool is a socket tool, or a crescent head tool wherein the friction breaking tool is a socket tool and the handle is a breaker bar handle or a ratchet handle.

[0025] In another embodiment, the handle of the friction breaking tool is operatively associated with a pneumatic, electric drive system, or hydraulic drive system to assist with the transfer of a rotational force when the friction breaking tool is operated by a user.

[0026] In still a further embodiment, the friction breaking tool fits over, or around a portion of the outer surface of the shoe's annular wall and is a socket or crescent head tool.

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BRIEF DESCRIPTION OF THE DRAWINGS

[0027] These and other features of the invention will become more apparent in the following detailed description in which reference is made to the appended drawings.

[0028] FIG. **1:** An exploded view of an exemplary core drill system according to prior art.

[0029] FIGS. **2A-2B: A** is a perspective view of a lower shoe of a shoe assembly modified for ergonomic removal and replacement of the assembly relative to an inner tube pipe according to an embodiment of the present invention; **B** is an exploded view of a shoe assembly.

[0030] FIG. **3:** An end view of the lower shoe portion of the shoe assembly of FIG. **2B**.

[0031] FIG. **4:** A perspective view of the lower shoe of the shoe assembly of FIG. **2B** depicting core breaker tool.

[0032] FIG. **5:** A partial overhead view of a ratchet socket tool for breaking the threaded connection between the shoe and the inner tube pipe.

[0033] FIG. **6:** A block diagram depicting an inner tube pipe with a shoe in position for core sample removal according to an embodiment of the present invention.

[0034] FIG. **7:** An isometric view of a pneumatic ratchet tool with a socket tool containing set screws which are aligned to fit into slot indentations on a shoe.

[0035] FIG. **8:** An isometric view of an off axis power transmission which powers a crescent head tool configured to interface with orthogonal blind seats contained on a shoe.

[0036] FIG. **9:** An isometric view of a ratchet socket tool for coupling with the shoe using a complementary coupler system of one or more protrusions and one or more indentations on a shoe and a socket.

[0037] FIG. **10:** An isometric view of a ratchet socket tool for coupling with the shoe with one of more protrusive elements and one or more indentations on the shoe and the ratchet tool.

[0038] FIG. **11:** An isometric view of an open-ended manual socket tool configured to couple with a shoe.

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DETAILED DESCRIPTION

[0039] In various embodiments described in enabling detail herein, the inventor provides a unique system for removing and replacing the shoe attached to an inner tube pipe of an earth core drilling apparatus. An objective of the invention is to reduce the manual labor currently required to remove and replace the shoe, thereby reducing the potential for injury to production bench workers performing the operation.

Definitions

[0040] Unless defined otherwise, all technical and scientific terms used herein have the same meaning as commonly understood by one of ordinary skill in the art to which this invention pertains.

[0041] The use of the word "a" or "an" when used herein in conjunction with the term "comprising" may mean "one", but it is also consistent with the meaning of "one or more", "at least one", and "one or more than one".

[0042] As used herein, the terms "comprising", "having", "including", "containing", and grammatical variations thereof, are inclusive or open-ended and do not exclude additional, unrecited elements and/or method steps. The term "consisting essentially of" when used herein in connection with a device denotes that additional elements and/or method steps may be present, but that these additions do not materially affect the manner in which the recited device functions. The term "consisting of" when used herein in connection with a device excludes the presence of additional elements and/or method steps. A device described herein as comprising certain elements and/or steps may also, in certain embodiments consist essentially of those elements and/or steps, and in other embodiments consist of those elements and/or steps, whether or not these embodiments are specifically referred to.

[0043] As used herein, the term "about" refers to an approximately +/-10% variation from a given value. It is to be understood that such a variation is always included in any given value provided herein, whether or not it is specifically referred to.

[0044] The recitation of ranges herein is intended to convey both the ranges and individual values falling within the ranges, to the same place value as the numerals used to denote the range, unless otherwise indicated herein.

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[0045] The use of any examples or exemplary language, e.g. "such as", "exemplary embodiment", "illustrative embodiment", "an embodiment", "another embodiment", "prototypic embodiment", "in one embodiment", and "for example" is intended to illustrate or denote aspects, embodiments, variations, elements or features relating to the invention and not intended to limit the scope of the invention.

[0046] As used herein, the terms "connect", "connected", and "connection" refer to any direct physical association or positioning between elements or features of the assembly of the present disclosure. Accordingly, these terms may be understood to denote elements or features that are partly or completely contained within one another, attached, coupled, seated, hosted or encased inside of, disposed on, joined together, plumbed, threaded or ported into etc., even if there are other elements or features intervening between the elements or features described as being connected.

[0047] As used herein the term "tool", "breaking tool", and "friction breaking tool" all refer to an apparatus that is operated by a user to connect and disconnect a shoe of a shoe assembly to another tubular body or component of an inner tube assembly. Typically, the tool is configured to facilitate breaking the friction lock between threaded components. Examples of tools, such as a wrench, a ratchet and socket, a ratchet and socket wrench, a torque busting tool, a breaker bar and socket, all enable a user to operate said tool to break a friction lock between cylindrical (tubular) components, such as the shoe and the inner tube pipe, or a lower shoe and upper shoe.

[0048] As used herein, the term "interface" refers to where the surface of a first component and the surface of a second component come into contact and sufficient engagement with one another to facilitate an operation using an inner tube assembly. For example, in the present disclosure, a "shoe interface" allows a user to transfer rotational force from a tool to a shoe.

[0049] As used herein, the terms "core" and "earth core" refer to a cylindrical section of earth resulting from a rotating drilling bit cutting a section of rock, clay, silt, sand, or more generally cutting earth. Earth cores may be various sizes from about 10mm to 300mm in diameter, and conceptually could be about 12 km in length, and are typically extracted in 1 meter to 9 meter increments. Within the core drilling industry, earth core is extracted from the earth using drilling rig equipment, specifically core drilling inner

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and outer barrels, and may be delivered to a laboratory for scientific and geotechnical analysis.

[0050] As used herein, the term "inner tube assembly" refers to a multi-component apparatus (as exemplified in FIG. **1**) which encases and retains core during the core drilling and retrieval process inherent to a core drill. The term "inner tube assembly" may be used interchangeably with "inner tube" herein. For example, the inner tube assembly includes the componentry which is lowered into the drill string and core barrel, and used in the core drilling process, and which is then retrieved and laid horizontally on a workbench. The inner tube assembly includes a shoe assembly, an inner tube pipe, a bearing, a latch, and a check valve amongst other components.

[0051] As used herein, the term "inner tube pipe" refers to a cylindrical component of the inner tube assembly that an earth core slides into during the core drilling process. The inner tube pipe encases the core, but does not retain it within the inner tube assembly.

[0052] As used herein the term "shoe" refers to an annular or otherwise cylindrical (tubular) component of an inner tube assembly that can host a core retention mechanism (such as core breakers or basket catchers), and prevents the core from sliding out of the inner tube assembly during the core retrieval process. A shoe will generally have at least one end that is configured with a threaded connection means so that it can be connected or disconnected from another tubular body of the inner tube assembly. The use herein of the related term "shoe assembly" refers to the combination of one or more tubular bodies, each body fitted with a core retention mechanism, and at least one threaded connection means to facilitate the assembly or disassembly of an inner tube assembly. When a shoe assembly consists of a single shoe and its core retention mechanism, said shoe may connect to and disconnect from an inner tube pipe.

[0053] As used herein the term "core breakers" may be used interchangeably with "breakers", "lifters", or "core lifters", and refer to a conical open-sided, open-ended spring with internal barbs which uses a relative upward motion and conical housing contained in the shoe to grip, contract, and then break earth core from the earth.

[0054] As used herein the term "basket catchers" refers to a core retention mechanism which utilizes radially aligned biased springs to retain core within an inner tube pipe. Basket catchers are commonly housed within the upper shoe component.

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[0055] As used herein the term "lower shoe" may be used interchangeably with "lower tubular body" or "lower shoe component" and refers to a lower tubular body within a shoe assembly. A lower shoe may be part of a shoe assembly which hosts one or more annular (tubular) components. Typically a lower shoe assembly will also host core breakers when in use with the rest of an inner tube assembly.

[0056] As used herein the term "upper shoe" may be used interchangeably with "upper tubular body" or "upper tubular component" and refers to a tubular body of a shoe assembly where each end is threaded, one of those threaded connection means being used to connect and disconnect with an inner tube pipe of an inner tube assembly. The upper shoe may also thread (removably connected) onto the lower shoe, or connect and disconnect from (removably connected) other tubular bodies. Typically, an upper shoe will also host basket catchers.

[0057] As used herein the term "middle shoe" refers to a component of a shoe assembly that may be removably connected between a lower shoe and an upper shoe, when used within a shoe assembly with three or more cylindrical (tubular) bodies.

[0058] As used herein the term "coupling surface" refers to a raised surface (protrusion), or a depressed surface (indentation) along a wall surface (outer or inner) of an annular component or partially (semi) annular component (e.g. shoe or tubular body). The coupling surface is applied to and enables the transfer of a rotational force between a first component to a second component. A raised coupling surface may be formed by machining (subtracting) a portion of an annular component or be an object inserted through the wall surface of the annular component. Such objects may include screws, insertable keys, machined keys, stock, or pins, or any object that is configured to be fitted into a depressed coupling surface of another component. For example, depressed coupling surfaces such as indentations may be formed by machining a portion of a cylindrical component to provide a slot, hole, face, or other depressed surface. Raised (protrusion) and depressed (indentation) coupling surfaces may be arranged along the wall of the respective annular or semi-annular component in an equidistant or non-equidistant pattern relative to one another provided that they can be aligned with one another to create the desired engagement between said paired coupling surfaces.

[0059] As used herein the term "pairing(s)" denotes complementary coupling surfaces between a first component and a second component that can be aligned with one another when

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the first and second components are engaged with each other. There can be a single pairing or multiple pairings of such coupling surfaces along a surface of the first component that comes into contact with a surface of the second component. A reference to a single pairing may refer to a first coupling surface (e.g. an indentation) and its complementary coupling surface (e.g. a protrusion). Alternatively, a single pairing may refer to a single indentation and a grouping of protrusions that can be aligned with and fitted into the indentation.

[0060] As used herein the term "coupling interface" refers to a connection between a raised coupling surface (protrusion) hosted on a first component and a depressed coupling surface (indentation) hosted on a second component which contributes to providing sufficient engagement between said first and second components (e.g. a shoe and tool) for the transfer of a rotational force. A "complementary coupling interface" refers to the totality of coupling interfaces between a shoe and tool, or aligned pairings of complementary indentations and protrusions between a shoe and tool. A complementary coupling interface may comprise a single pairing of an indentation and protrusion, or several pairings, e.g. 2, 3, 4, 5, 6 or more pairings.

[0061] As used herein the terms "coupling pattern" may be used interchangeably with "pipe coupling", "coupling", or "torque pattern" and refers to a totality of physical features used to facilitate the engagement between an outer surface of the annular wall of a shoe and the contact surface of an annular component (structure) of a tool, wherein one of said features is one or more pairings of indentations and protrusions on said surfaces forming a complementary coupling interface. The coupling pattern enables a first component to transfer a rotational force to a second component. For example, a coupling pattern applied between a wrench or socket engaged with a shoe allows the user of the tool to transfer rotational force to the shoe.

[0062] As used herein the term "orthogonal blind seats" may be used interchangeably with "flats", "seats", "blind seats", or "machined seats" and refer to planar indentations on a surface of a cylindrical pipe component which allow a crescent-headed wrench to slip over to provide a coupling pattern for a crescent-headed wrench from the side of a pipe component.

[0063] As used herein the term "friction lock" may be used interchangeably with "thread lock" and refers to a force which resists the separation of two cylindrical threaded pipe

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components. Friction lock may use thread design to bottom out the threads against a flanged face which in turn compresses the male threads against female threads, and results in a resisting force to the removability of male from female thread. Friction/thread lock may be used to connect or disconnect a specific threaded connection within a series of threaded connections by loosening or tightening, respectively, targeted threaded components to a lower friction spec than other threaded connections.

[0064] As used herein the term "off axis power transmission" refers to a powered drive system which rotates a socket or crescent head, or open-ended socket tool from its side, the motor of the said drive system being positioned with a radial offset from the longitudinal axis of the inner tube threads, and using a belt, gears, pulleys, chains, friction, or other drive system to transfer rotational force to an interface contained on the longitudinal axis on the inner tube assembly. Off axis motors allow for the use of open-ended sockets, or motorized crescent heads.

[0065] It is contemplated that any embodiment of the compositions, devices, articles, methods, and uses disclosed herein can be implemented by one skilled in the art, as is, or by making such variations or equivalents without departing from the scope and spirit of the invention.

[0066] While the following description and the figures detail certain embodiments to illustrate and exemplify the invention, it is to be understood that the invention is not limited by the details of the construction and specific illustration of such embodiments which follows.

Tubular Components of Inner Tube Assembly within a Core Drilling System

[0067] In the field and prior art, tubular components of inner tube assemblies (see example in FIG. **1**) used in core drilling systems typically thread together to facilitate the assembly and disassembly of an inner tube assembly. Within the prior art, pipe wrenches, chain tongs, or chain wrenches are utilized to create a friction interface between a tubular component's outer wall surface and a contacting surface of a tool so that a user can transfer a rotational force to assemble and disassemble tubular components. Wrenches may use pivotally affixed jaws to create a friction interface between a tool and a shoe of a shoe assembly.

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[0068] According to the present disclosure, the engagement between the outer wall surface of the shoe and contacting surface of the tool is enhanced by applying depressed and/or raised surfaces positioned along the outer wall surface of the shoe that are complementary to corresponding raised and/or depressed surfaces hosted along the contacting surface of the tool. The (complementary) pairings of such coupling surfaces form a complementary coupling interface that contributes to the shoe interface's overall coupling (torque) pattern.

[0069] The protrusions and/or indentations positioned along the outer wall surface of a shoe may be selected to align and engage with protrusions and/or indentations already existing on the contacting surface of the tool, or the contacting surface of the tool may be adapted to present complementary indentations and/or protrusions that align and can be fitted with the protrusions and/or indentations of the shoe's outer wall surface.

[0070] In one embodiment, the outer surface of an annular wall of a shoe has an indentation or a protrusion. In a related embodiment, the indentation or the protrusion of the annular wall of the shoe can be aligned and fitted with a complementary protrusion or indentation on the contacting surface of a tool.

[0071] In another embodiment, the outer surface of an annular wall of a shoe has one or more indentations and one or more protrusions. In a related embodiment, the one or more indentations and one or more protrusion of the annular wall of the shoe can be aligned and fitted with a complementary protrusion(s) and indentation(s) on the contacting surface of the tool.

[0072] In a further embodiment, the outer surface of an annular wall of a shoe has one or more indentations. In a related embodiment, the one or more indentations of the annular wall of a shoe can be aligned and fitted with one or more complementary protrusions on the contacting surface of the tool.

[0073] In still another embodiment, the outer surface of an annular wall of a shoe has one or more protrusions. In a related embodiment, the one or more protrusions of the annular wall of a shoe can be aligned and fitted with one or more complementary indentations on the contacting surface of the tool.

[0074] In yet another embodiment, the outer surface of an annular wall of a shoe has one or more indentations. In a related embodiment, each indentation is configured to receive grouped protrusions on the contacting surface of the tool that can be aligned and fitted

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into each indentation.

[0075] In still another embodiment, the outer surface of an annular wall of a shoe has one or more groupings of protrusions. In a related embodiment, each grouping of protrusions can be aligned and fitted into an indentation on the contacting surface configured to receive said grouping of protrusions.

[0076] FIG. **1** is an exploded view of an exemplary core drill system **100** according to prior art. Core drill system **100** includes a cylindrical core barrel **101** having a heavy coring bit **103**, and an inner tube assembly **102** designed to operate within core barrel **101** to slide over a stationary core and separate a core sample for retrieval and analysis. Core barrel **101** is cylindrical and somewhat larger in diameter than inner tube assembly **102** which is adapted to have an inside diameter that may slide over a stationary centered core sample produced by coring bit **103**. Inner tube assembly **102** has an outside diameter somewhat smaller than the inside diameter of core barrel **101** to enable lowering of the inner tube assembly into the core barrel and retrieving the assembly back out of the barrel. Inner tube assembly **102** fits into core barrel **101** according to the direction of the depicted arrows. Inner tube assembly **102** latches inside core barrel **101** prior to the drilling process via a latch system **104**, a machined feature **117**, and landing ring **116**.

[0077] Inner tube assembly **102** includes all of the components needed to slide down around a stationary core, and in conjunction with an upward relative force provided by the drilling rig to separate a measured section of that core, and retain the separated core sample section within the inner tube assembly. The inner tube assembly **102** can then be retrieved by wire line, using a latch **115** for example, and an empty inner tube assembly **102** may then be attached to the drill equipment wire line and lowered back down into core barrel **101** to capture a next sample. The inner tube assembly **102** may include a latching head section **115** at the top that operatively connects with a drill equipment suspending apparatus. Inner tube assembly **102** may include a bearing **105** connected to a lead-screw mechanism **114** on top, and to an inner tube pipe **106**. Lead-screw mechanism **114** may hold a landing nut **109** which, after lowering the inner tube assembly into the core barrel, is suspended by the core barrel landing ring **116**.

[0078] Inner tube pipe **106** may include a check valve **107**, which may be a ball check valve. Inner tube assembly **102** may further include a plastic lining pipe **108** adapted with an outside diameter just smaller than the inside diameter of the inner tube pipe **106**. The

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inside diameter of lining pipe **108** is just large enough to slide over a stationary core with a cylindrical diameter variation of about 0-2mm between the earth core and the internal diameter of the pipe. The inner tube assembly may further include a plastic pipe lining pipe **108** adapted with an outside diameter just smaller than the inside diameter of the inner tube pipe **106**. Liner pipe **108** slides up into inner tube pipe **106**.

[0079] Inner tube assembly **102** includes a lower shoe component **112** (lower tubular body) in the shoe assembly, with the lower shoe component **112** hosting a core breaking tool **113** (not visible). Lower shoe component **112** may be somewhat larger in outside diameter than the upper shoe component **111**. Outside diameters of shoe components **112** (lower shoe) and **111** (upper shoe) may vary according to a desired core diameter, which may range from one and one-half inches to several inches in diameter depending on system and operation. A shoe assembly containing an upper shoe component **111** with a basket catcher apparatus **110** is adapted to be installed (threaded) onto the lower end of inner tube pipe **106**. Basket catcher **110** is contained within the inside diameter of upper shoe component **111** and functions to retain hold of a separated core sample.

[0080] When assembled, the only visible parts of the inner pipe assembly **102** are lower shoe component **112**, upper shoe component **111**, inner tube pipe **106**, rig-latching head **104**, lead-screw mechanism **114**, landing nut **109**, bearing **105**, and a bearing crossover assembly **118**. In the operation of extracting core samples, connection between the upper shoe component **111** and the inner tube pipe **106** must be loosened and the shoe threaded off from the inner tube pipe **106**. Inner tube pipe **106** has external threads that match a female thread pattern on the inside top end of upper shoe component **111**. To extract a core sample, the shoe must be removed from the inner pipe assembly **102** and replaced once the core sample is removed from the inner pipe assembly.

[0081] Unlike the shoe components **111** and **112** in FIG. **1**, FIGS. **2A/2B-11** illustrate how the outer surface of an annular wall of a shoe can be adapted with one or more coupling surfaces that are complementary to coupling surfaces on a contacting surface of a tool used to engage with the shoe in order to connect and disconnect it from another tubular body of an inner tube assembly. This complementary arrangement of raised and depressed surfaces when aligned and fitted with one another form a complementary coupling interface that contributes to the coupling (torque) pattern used to translate a rotational force from the tool to the shoe to enable its connection or disconnection from the other tubular body.

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Breaking Tool

[0082] An annular or partially (semi) annular (friction) breaking tool hosting one or more coupling surfaces along its inner annular (contacting) surface, comprising raised and/or depressed surfaces may form a (complementary) coupling interface with raised or depressed surfaces on the outer surface of a wall of a shoe. Different tool types configured for breaking a friction lock created using a threaded connection means may be thus adapted according to the present disclosure to create a shoe interface system as described herein.

[0083] In one embodiment illustrated in FIG. **5**, keys **504** are presented on the internal surface of a socket tool **501**, and may be used to form a (complementary) coupling interface with slots **203** as illustrated in FIG. **4**.

[0084] In one embodiment illustrated in FIG. **7**, groupings of screws **701** provide an internal raised surface(s) on the internal surface of the annular socket tool. Each grouping of screws **701** may interface (align) and be fitted into each slot **203** found on the outer surface of the shoe to form a coupling interface.

[0085] In another embodiment illustrated in FIG. **8**, a coupling surface **801** is hosted on the internal surface of a partially (semi) annular tool (e.g. a crescent-headed wrench). The coupling surface of the crescent-headed wrench **801** may interface (align and be fitted into) an orthogonal blind seat **208** to contribute to the formation of a coupling interface.

[0086] In yet another embodiment illustrated in FIG. **9**, a coupling surface is formed on the internal surface of the annular socket tool. Coupling surface **901** may be a pin which may be retractable to access the coupling surface **902** on the shoe illustrated in FIG. **9**.

[0087] In one embodiment illustrated in FIG. **10**, a coupling surface **901** hosted on the internal surface of an annular socket tool may form a coupling interface with coupling surface **902** which is hosted on the external surface of a shoe.

[0088] In one embodiment illustrated in FIG. **11**, open-ended socket tool **501** hosts keys **504** on its inner annular surface which may form a coupling interface with slots **203** contained on the outer annular surface of the shoe illustrated in FIG. **11**.

[0089] The present invention is described using the following examples, which may describe more than one relevant embodiment falling within the scope of the invention.

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EXEMPLARY EMBODIMENTS

[0090] The following example(s) illustrate the various aspects and embodiments of the shoe, shoe interface system, and methods of the present disclosure.

[0091] FIG. **2A** is a perspective view of a lower shoe component **112** modified for ergonomic removal and replacement of a shoe relative to an inner tube pipe according to an embodiment of the present invention. FIG. **2B** is an exploded view of the lower and upper shoe components and an inner tube pipe. Lower shoe component **112** is a heavy thick-walled pipe that has a female pipe threading classified as a fine thread pattern **202** on the inside diameter that accepts a male thread pattern on the external surface of the upper shoe component **111**. Inner tube pipe **106** (see FIG. **6**) has a male external thread pattern on a thin wall pipe form which fits into a female thread pattern on the inside diameter surface of the upper shoe component **111**. Referring now to FIG. **2B**, shoe assembly **200** includes an upper shoe component **111** which has a relatively large diameter pipe and exists in a field where dirt, sand, grit, and tar create friction between the threaded connection on the shoe and the inner tube pipe **106**. Significant force may be required to break the friction lock of the mated threads to unscrew the shoe from inner pipe **106**. The external male threads on inner pipe **106** are referenced herein as threads **207**. The mating female threads on upper shoe component **111** are referenced herein as threads **209**. In one embodiment, it is desired that the shoe assembly **200** (lower shoe component **112** and upper shoe component **111**) be unscrewed as a rigid tightly threaded (greater friction lock) assembly from the end of inner tube pipe **106**.

[0092] The larger diameter of the lower shoe component **112** prevents access by socket tool to the upper shoe component **111**, which may have machined flats **208** provided thereon for connecting a pipe wrench.

[0093] The annular form of the shoe acts in conjunction with hydraulic fluid and the bearing assembly to minimize yaw and tilt of the inner tube pipe during drilling operations making the provision of flats on the outside surface of the lower shoe for fitting a pipe wrench detrimental to the assembly.

[0094] Additionally, in many core drilled formations the pressurized hydraulic fluid discharging around the annular form of the lower shoe may play an important role in cutting a cylindrical core from the earth and in cleaning the bit of certain types of core build ups. In particular if the inner tube assembly **102** tilts or yaws relative to the core

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barrel, the core may jam and thereby plug the inner tube orifice prior to the end of the core drilling cut. Inner tube assembly yaw and tilt may also cause the core to become deformed into an ovular form, which can potentially cause core slippage during wireline retrieval.

[0095] A pipe wrench which grips on only two surfaces of the shoe creates an increased risk of marring or ovalling of the shoe. On the outside diameter the shoe must remain annular due to the tolerances with the rotating polygonal inside diameter shape of the core bit, and also for even distribution of discharging hydraulic fluid. Discharging hydraulic fluid plays a crucial role within the lubrication of the core as it enters the inner tube assembly, cleaning the bit, and in some earth formation cutting the core with hydraulic pressure. Core drillers may set and change the distance between the lower shoe and core bit using the lead screw mechanism **114** and landing nut **109** depending on which earth formation they are within, as fluid discharge pressure is a key parameter of core successful core drilling. Providing flats for fitting a wrench on lower shoe component **112** similar to flats **208** on upper shoe component **111** may be detrimental to the shoe due to the possibility of yaw, and uneven fluid discharge.

[0096] A consequence of utilizing tool steel dies to grip the shoe is that a relatively softer material, such as 4140 molybdenum alloy steel, may be used for the shoe, which decreases the lifespan of the shoe itself relative to harder materials; the threads wearing faster, and the annular form becoming marred, or distorted quicker. The use of tool steel dies to grip the shoe relatively decreases the lifespan of the shoe's annular form, as the dies require slight deformation of the surface of the shoe to grip it. Alternatively, keys **504** (of FIG. **5**) may use relatively softer material, such as brass, aluminum, or copper to transfer torque to slots **203** (of FIG. **4**), the keys **504** being replaceable. Since the keys may be made out of a softer material than the shoe, the keys wear instead of the shoe.

[0097] Referring now back to FIG. **2A**, in this embodiment, lower shoe component **112** has a larger diameter then the upper shoe component **111** when threaded together due to the thicker wall. A substantial amount of surface material, perhaps half of the pipe thickness, may be removed by lathe from the outside surface of lower shoe component **112** forming a step-down feature **201** leaving a smaller concentric diameter **204** extending to the end of the lower tubular body. At the free end of lower shoe component **112** the pipe thickness is machined to provide a taper down feature **205**.

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The pipe wall has greater thickness at the free end of the lower tubular body, the lower tubular body also presenting a smaller diameter at the free end. The inside of the free end of the pipe has an inside taper producing a conical inside surface for hosting an internal core breaker ring designed to help separate a core sample from a stationary core resulting from drilling. A plurality of elongated slots **203** are machined longitudinally along the outside surface of lower shoe component **112** to form a torque pattern of slots for securely positioning and seating a torque busting tool (not illustrated here) that may be attached to or otherwise fitted over the outside surface of lower shoe component **112**. Such a tool may include a leverage handle or pneumatic power interface that can be used in place of a gripping pipe wrench to break the thread lock so unscrewing the shoe from the end of the inner pipe is possible without tool slippage that may mar the outside surface of the pipe material. Electric and hydraulically powered socket tools may be used instead of a pneumatic tool without departing from the spirit and scope of the present invention.

[0098] In one embodiment, there may be two elongated parallel slots **203** provided on opposite sides of lower shoe component **112**. In other embodiments, an equally spaced array of parallel slots **203** may present a three-slot pattern, a four-slot pattern, a star pattern (five slots) and so on. In alternative embodiments, slots **203** may be spaced unequally without departing from the spirit and scope of the invention. In this embodiment, slots **203** break out of both ends of the thicker wall of material comprising the center portion of lower shoe component **112**. That is not required in order to practice the invention as long as the slot pattern **203** breaks out to the free end of the pipe allowing a tool like a deep socket with a key pattern that matches the slot pattern to be placed over the lower shoe component **112** from the free end wherein the key pattern engages the slot pattern **203**. In this embodiment, slots **203** break out of both ends of the thicker wall of material comprising the center portion of the lower shoe. That is not required in order to practice the invention as long as the slot pattern breaks out to the free end of the pipe allowing a tool like a deep socket with a key pattern that matches the slot pattern to be placed over the lower shoe from the free end wherein the key pattern engages the slot pattern. In an alternative embodiment, the lower tubular body does not include a step-down feature like feature **204**. In still another embodiment, the larger diameter pipe of the lower shoe and slots extend to the upper shoe, the threads machined to enable the slots of the upper shoe component **111** and the lower shoe component **112** to align.

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[0099] In yet another embodiment only a lower shoe is used, in such an embodiment if basket catchers **110** are used they fit within the lower shoe. In yet another embodiment, slots extend from the lower shoe component **112** to the upper shoe **111** regardless of pipe diameter, the threads being machined to line up the slot pattern when assembled.

[0100] Referring now to FIG. **2B**, inner tube pipe **106** includes male (external) thread pattern **207** on thin wall pipe which fits into female (internal) thread pattern **209** on upper shoe component **111**. The components are aligned in the orientation of assembly as indicated by the directional arrows.

[0101] FIG. **3** is an end view of the lower tubular body of FIG. **2A**. In this view looking directly into the slotted end of lower shoe component **112**, it may be seen that the torque pattern of slots **203** is a star pattern. Slots **203** have a keyway architecture having a width and a depth and a relatively flat floor. A key architecture for slots **203** is not required to practice the invention. Slots **203** may comply to a variety of available geometric slot or keyway designs so long as the key apparatus on the torque busting tool engages the slot pattern **203** securely such that the tool does not come off or slip out of the slot pattern when being used to break the friction lock of the threaded interface.

[0102] Step down surface **204** is preferably concentric with the outside diameter of lower shoe component **112**. Wall **201** depicts the stepped down wall marking the ends of slots **203**. In one embodiment, a socket device may be fabricated with a matching key pattern that may be slipped onto the free end of lower shoe component **112** far enough along the longitudinal axis of the pipe material to engage the key pattern into the slot pattern. A socket device may be fashioned to fit a breaker bar or sturdy ratchet handle functioning as a lever that may be operated to loosen the interface between the shoe assembly and the inner tube pipe. The internal diameter of lower shoe component **112** has a conical taper in a wall thickness **301** to provide a seat for a core breaker apparatus (not illustrated).

[0103] FIG. **4** is a perspective view of lower shoe component **112** of FIG. **2A** depicting a core breaker tool **113** introduced in FIG. **1** above but not visibly illustrated. Three slots **203** of a star pattern are visible in this perspective view. In this view, the free end of the lower shoe component **112** is depicted in perspective and includes core breaker tool **113** contained within the pipe form at an angle formed by the conical taper feature

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described further above machined on the inside of the pipe. In this view, the slot pattern comprising slots **203** terminates before breaking out at the slotted end of the shoe. Three slots of a star pattern are visible in this perspective view.

[0104] FIG. **5** is a partial overhead view of a socket tool **501** for breaking the threaded connection between the shoe assembly (between the upper shoe component) and the inner tube pipe, and for force-tightening the shoe to the inner tube pipe. A socket tool **501** is provided in this embodiment that includes a star pattern key array of keyways **504** that may be manually slipped over the diameter of the shoe components and into the slot pattern operating from the free end of lower shoe component **112**.

[0105] Elongated keys **504** are square keys in this embodiment that have a width dimension just smaller than the inside diameter of the slots. Socket tool **501** may be modified at the back wall with a center opening that may fit a square key of a breaker bar handle **502**. In addition to a square key, any geometric pattern may be used to couple a socket tool to a breaker bar. In this case a breaker bar (not pictured) may be leveraged by handle **502** to break the thread lock keeping the shoe and inner tube pipe **106** tightly threaded together before the shoe remaining fictionally joined may be removed from the inner tube pipe **106**.

[0106] In one embodiment, the breaking tool is a ratchet tool having a bi-directional ratchet disc **503**, a drive square **505**, and a handle **502** allowing the socket tool **501** to be used entirely for screwing the shoe on to the inner tube pipe. In one embodiment, the ratchet tool may be a pneumatic tool that uses compressed air to spin the socket in the two directions saving workers from manual threading operations which may be difficult with fine pipe threads that tend to become sticky or otherwise friction tight and resist movement, or may be friction locked to the part or all of the 3 meter core sample by the result of drilling practice and core breakers.

[0107] In another embodiment illustrated in FIG. **7**, set screws are inserted through the annular body of the socket tool to form raised surfaces on the socket's inner annular surface. Coupling surface **701** are formed by aligning one or more set screws or pins so that the screws form internal raised surfaces which may couple with slots **203** hosted on the shoe. Other insertable objects may be used to insert into the socket tool such as pins, keys, or other objects.

[0108] FIG. **6** is a block diagram **600** depicting an inner tube pipe with an intact shoe

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assembly in position for core sample removal according to an embodiment of the present invention. Inner tube pipe **106** containing a core sample for removal is placed horizontally onto a workbench **601** so bench line workers can remove the shoe to retrieve the core sample. In this example, a vice apparatus **602** may be provided at the end of bench **601** and used to hold the inner tube pipe **106** in a fixed state preventing the inner tube pipe **106** from rotating on the bench. In this position, lower shoe component **112** is suspended by vice apparatus **602** at the very end of the workbench **601** so the free end is accessible to socket tool **501** using handle **502**. In one variant embodiment, the bench **601** extends past the vice and could interfere with a breaker bar or a long handle. In such a case the socket tool may be operated by a pneumatic system, an electric drive system, or a hydraulic drive system. With the use of pneumatics, hydraulics, or electric power, handle **502** may not be specifically required to practice the invention.

[0109] A bench worker may place socket tool **501** over the free end of lower shoe component **112** from FIG. **4** in the direction of the arrow with the key pattern on the inside diameter of the socket tool **501** engaging the slot pattern **203** on the lower shoe component **112**. In this position, inner tube pipe **106** is suspended by the vice at the very end of the workbench **601** so the free end is accessible to socket tool **501**. An additional configuration may be provided by extending the step down feature to the upper shoe component **111**. In another configuration, blind seats may be used. Handle **502** may be leveraged with relative minor force to unlock the threaded interface between the shoe and the inner pipe.

[0110] After the thread lock is overcome, rotation of the shoe may need to overcome friction related to the core retention mechanisms and their friction lock to the core. A typical embodiment of the invention uses a high torque mode, for example, a breaker bar which leverages a manually produced force to break the initial thread lock. After the high torque mode of the tool overcomes the initial high friction resistance to rotation, typically the tool will use a high speed method of rotation, for example a pneumatic, electric, or hydraulic drive which spins a socket tool. An additional method of high speed rotation is to use a 90 degree handle attached to the breaker bar, offset and parallel to the longitudinal axis of the inner tube assembly which acts as a crank handle to spin the socket, and the shoe's threaded connection. Within the method of using a manual hand crank for high speed rotation, a segment of the breaker bar can pivot 90 degrees to turn into a crank handle. The shoe assembly contains all of the components

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which host core retention mechanisms, typically the upper and lower shoe (**111** and **112**, respectively), core breakers **113**, and basket catchers **110**. To break the friction lock of the shoe's threaded connection, the shoe must rotate relative to the inner tube pipe.

[0111] After the core sample is secured, the shoe must be threaded back onto the inner tube pipe. The same tool may be used to re-thread the shoe's threaded connection to the inner tube pipe, and then tighten the threaded connection with sufficient force to establish the friction lock bottoming of the threads. To re-fasten the shoe's threaded connection typically the shoe spins relative to a stationary inner tube pipe. Sand, dirt, and tar can contaminate the threads **207** and **209** (referring to FIG. **2B**). To prevent thread damage a regulated pneumatic tool, an electric tool with a known maximum torque output, or a torque limiter which limits the force applied to the threads may be used. When initially threading the shoe's threaded connection onto the stationary inner tube pipe, the threads can become cross-threaded, hence a worker may manually thread the shoe's threaded connection onto the inner tube pipe **106** by hand about 1-2 turns to avoid cross-threading, and then use the socket tool **501** to spin the full length of threads to fully attach the shoe to the inner tube pipe **106**.

[0112] In one embodiment two separate tools can be used, one driving the socket tool **501** (referring to FIG. **5**) clockwise, and the other tool driving socket tool **501** counter clockwise. One tool of such a pair of tools may be dedicated to spinning the shoe off, and the other tool of the pair to spinning the shoe on. In a variation of this embodiment where two tools are used, a torque limiter can be used when fastening the shoe to the inner tube pipe, to set the torque of the shoe to a measurable and common thread lock, to ensure the shoe is substantially friction locked to the inner tube pipe for drilling. Conceptually it is possible to spin the inner tube pipe, relative to a stationary shoe using the socket tool described to hold the shoe stationary relative to a spinning inner tube pipe. It is also conceptually possible to spin both the inner tube pipe and the shoe in opposite directions to remove the shoe, and re-attach the shoe using the keyed pattern socket to spin the shoe.

[0113] In another embodiment of the present invention, automation may be used to remove the shoe after the friction lock of the threaded connection is broken using the socket tool **501** and breaker handle **502**. In one embodiment illustrated in FIG. **8**, in place of elongated slots, blind seats **208** may be placed around the perimeter of the lower

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tubular body, upper shoe component, or any place on the shoe wherein a breaker tool with a crescent head having matching protrusions **801** may be placed orthogonally over the shoe, provided that the seats are sufficiently far enough away from the free end of lower shoe component **112** to not impede stabilization and fluid discharge. For example, an aircraft automation wrench tool that is essentially two motors that spin an open-ended C-wrench. In this embodiment, a worker may place the tool over the pipe engaging the blind orthogonal seats **208** and then use a leveraged small amount of force to break the friction lock. Within embodiments using crescent heads which fit onto orthogonal blind seats **208**, an off axis pneumatic, electric, or hydraulic gear system **702** can be utilized to spin the crescent head and thereby spin the shoe in two directions, relieving the worker of manually threading.

[0114] Occasionally, the core sticks out of the lower shoe a few inches, in such cases a worker may break the core off using a hammer and chisel to allow a deep socket tool with a key pattern to reach slot pattern **203**, or use a deeper reach socket. However, FIG. **11** illustrates an embodiment which works around the occasional problem of the core sticking out of the inner tube assembly. FIG. **11** illustrates an open-ended socket tool **501** which allows the tool to slip over the annular space where a core sample might stick out onto lower shoe **112**, and utilizes a handle **502** which acts as a breaker bar that may pivot 90 degrees for the dual function of a hand-crank. In a variation of this embodiment, the breaker bar may contain a motor or an off axis power transmission, for example, a ring gear, or pulley system which is powered by pneumatics or hydraulics which spins the open-ended key-pattern from its side. In another embodiment of the present invention, automation may be used to remove the shoe from the inner tube pipe. In that embodiment, a machine may place the socket tool over the shoe engaging the indentations, seats, or slots and may produce a leveraged force to break the friction lock. A pneumatic, electric, or hydraulic driven socket tool allows automation to perform all of the threading operations, relieving the bench worker of threading by hand and therefore protecting the worker from potential injury over time.

[0115] In one embodiment illustrated in FIG. **9**, one or more protrusive elements **902** may couple with one or more indentations **901** on the shoe, enabling the transfer of rotational force. The indentation **901,** and protrusive element **902** may be hosted on either the socket or the shoe so long as they form a complementary pairing according to the present disclosure. For example, see FIG. **9** and FIG. **10**. In short, any

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configuration of pairings of indentations and protrusions can be used so long as the connection made when the coupling surfaces of a pairing are aligned contributes to the ability of a user to operate a tool to connect and disconnect a shoe from another tubular body/component.

[0116] It will be apparent to one skilled in the art that the coupling pattern on a wrench and complementary shoe tool of the present invention may be provided using some or all the elements described herein. The arrangement of elements and functionality thereof relative to the invention is described in different embodiments each of which is an implementation of the present invention. While the uses and methods are described in enabling detail herein, it is to be noted that many alterations could be made in the details of the construction and the arrangement of the elements without departing from the spirit and scope of this invention. The present invention is limited only by the breadth of the claims below.

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THE EMBODIMENTS OF THE INVENTION IN WHICH AN EXCLUSIVE PROPERTY OR PRIVILEGE IS CLAIMED ARE DEFINED AS FOLLOWS:

1. A shoe interface system comprising:

a) a shoe, the shoe having an annular form, with an open first end and an open second end, the ends being joined by an annular wall with an outer surface and an inner surface, at least one of said ends having a threaded connection means for connecting to and disconnecting from a tubular body of an inner tube assembly; and

b) a friction breaking tool comprising a handle connected at one end to an annular or semi-annular structure, the structure having a contacting surface that fits over, or around a portion of the outer surface of the shoe's annular wall;

wherein the portion of the outer surface of the shoe and the contacting surface of the friction breaking tool's structure each comprise one or more coupling surfaces that can be aligned with each other when said structure is fitted over or around the portion of the outer surface of said shoe to form a complementary coupling interface, thereby providing a coupling pattern to facilitate a transfer of a rotational force when the friction breaking tool is operated by a user to connect or disconnect the threaded connection means of the shoe to or from the tubular body of the inner tube assembly.

2. The shoe interface system of claim 1, wherein the complementary coupling interface comprises one or more pairings of coupling surfaces, wherein each pairing consists of an indentation and a protrusion that fits into said indentation when aligned with each other.

3. The shoe interface system of claim 1, wherein the one or more coupling surfaces of the outer surface of the shoe are indentations and the one or more coupling surfaces of the contacting surface of the structure of the friction breaking tool are protrusions.

4. The shoe interface system of claim 3, wherein there are one or more indentations and said indentations are positioned an equidistant or non-equidistant pattern relative to one another around the outer surface of the shoe.

5. The shoe interface system of claim 2, wherein the indentation is a slot oriented along a longitudinal axis of the shoe between the first and second ends of the shoe, or a seat disposed orthogonally to the longitudinal axis of the shoe.

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6. The shoe interface system of claim 2, wherein the structure of the friction breaking tool has been machined to provide the protrusion or is an object inserted through the contacting surface of the structure of the friction breaking tool.

7. The shoe interface system of claim 1, wherein the friction breaking tool is a socket tool, or a crescent head tool.

8. The shoe interface system of claim 1, wherein the friction breaking tool is a socket tool and the handle is a breaker bar handle or a ratchet handle.

9. The shoe interface system of claim 1, wherein the handle of the friction breaking tool is operatively associated with a pneumatic, electric drive system, or hydraulic drive system to assist with the transfer of a rotational force when the friction breaking tool is operated by a user.

10. A method of forming a shoe interface for use in core drilling using an inner tube assembly, the method comprising the steps of:

a) providing a shoe having an annular form, with an open first end and an open second end, the ends being joined by an annular wall with an outer surface and an inner surface, at least one of said ends having a threaded connection means for connecting to and disconnecting from a tubular body of an inner tube assembly; and

b) connecting a friction breaking tool to the shoe, the friction breaking tool comprising a handle connected at one end to an annular or semi-annular structure, the structure having a contacting surface that fits over, or around a portion of the outer surface of the shoe's annular wall;

wherein the portion of the outer surface of the shoe and the contacting surface of the friction breaking tool's structure each comprise one or more coupling surfaces that can be aligned with each other when said structure is fitted over or around the portion of the outer surface of said shoe to form a complementary coupling interface, thereby providing a coupling pattern to facilitate a transfer of a rotational force when the friction breaking tool is operated by a user to connect or disconnect the threaded connection means of the shoe to or from the tubular body of the inner tube assembly.

11. The method of claim 10, wherein the complementary coupling interface comprises one or more pairings of coupling surfaces, wherein each pairing consists of an indentation and a protrusion that fits into said indentation when aligned with each other.

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12. The method of 10, wherein the one or more coupling surfaces of the outer surface of the shoe are indentations and the one or more coupling surfaces of the contacting surface of the structure of the friction breaking tool are protrusions that can be aligned with and fit into the indentations.

13. The method of claim 12, wherein there are one or more indentations and said indentations are positioned equidistant from one another around the outer surface of the shoe.

14. The method of claim 11, wherein the indentation is a slot oriented along a longitudinal axis of the shoe between the first and second ends of the shoe, or a seat disposed orthogonally to the longitudinal axis of the shoe.

15. The method of claim 11, wherein the structure of the friction breaking tool has been machined to provide the protrusion, or a key inserted through the contacting surface of the structure of the friction breaking tool.

16. The method of claim 10, wherein the friction breaking tool is a socket tool, or a crescent head tool.

17. The method of claim 10, wherein the friction breaking tool is a socket tool and the handle is a breaker bar handle or a ratchet handle.

18. The method of claim 10, wherein the handle of the friction breaking tool is operatively associated with a pneumatic, electric drive system, or hydraulic drive system to assist with the transfer of a rotational force when the friction breaking tool is operated by a user.

19. A shoe for constructing a shoe interface system, the shoe having an annular form, with an open first end and an open second end, the ends being joined by an annular wall with an outer surface and an inner surface, at least one of said ends having a threaded connection means for connecting to and disconnecting from a tubular body of an inner tube assembly; and wherein the outer surface of the shoe has one or more coupling surfaces comprising indentations or protrusions which can be aligned with complementary protrusions, or indentations of a friction breaking tool to facilitate the connection and disconnection of the shoe from the tubular body of the inner tube assembly when the friction breaking tool is operated by a user.

20. The shoe of claim 19, wherein the friction breaking tool fits over, or around a portion of the outer surface of the shoe's annular wall and is a socket or crescent head tool.

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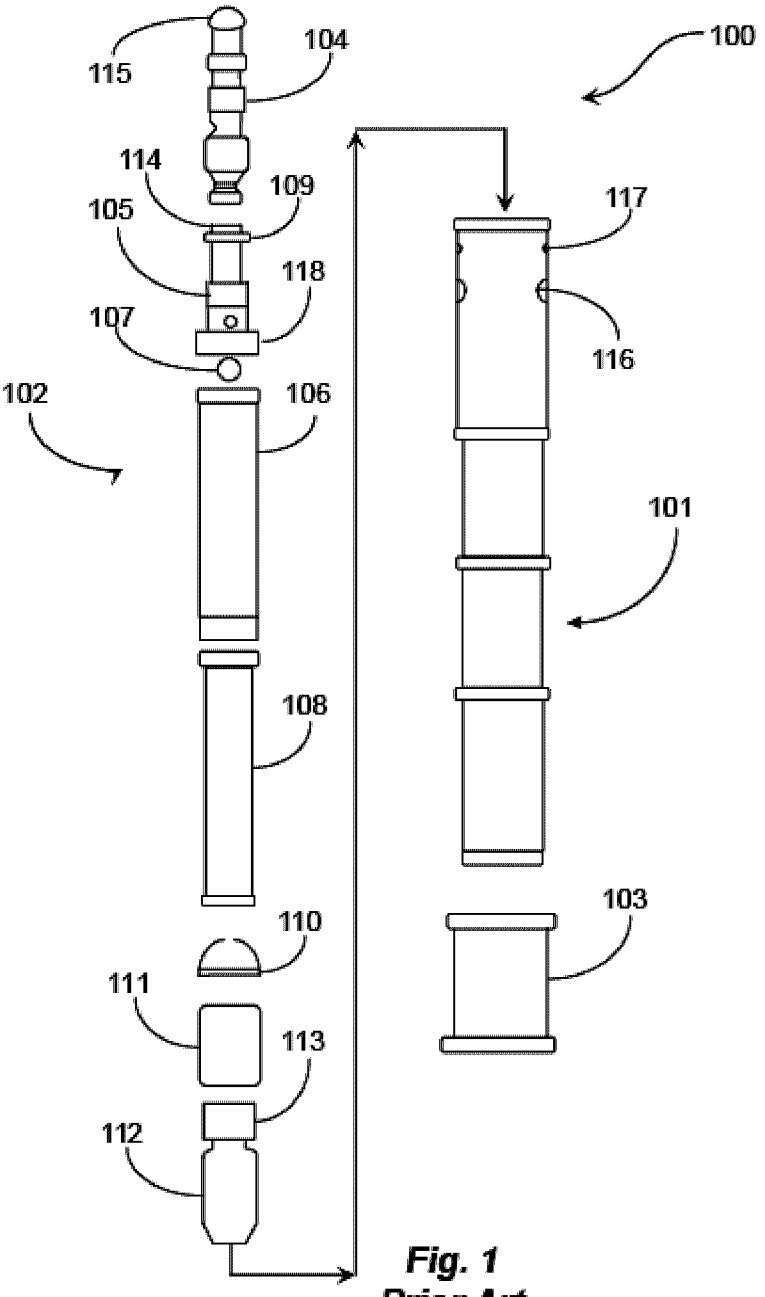


Fig. 1
Prior Art

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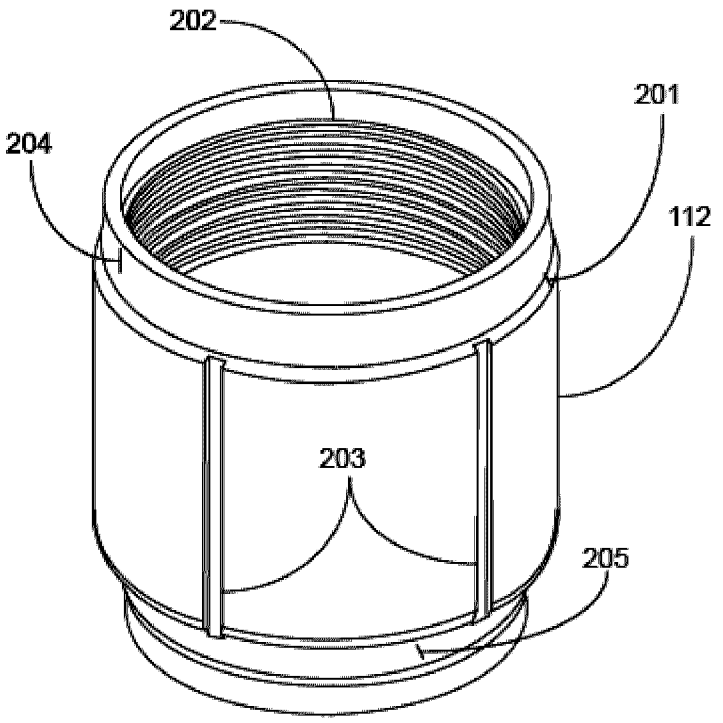


Fig. 2A

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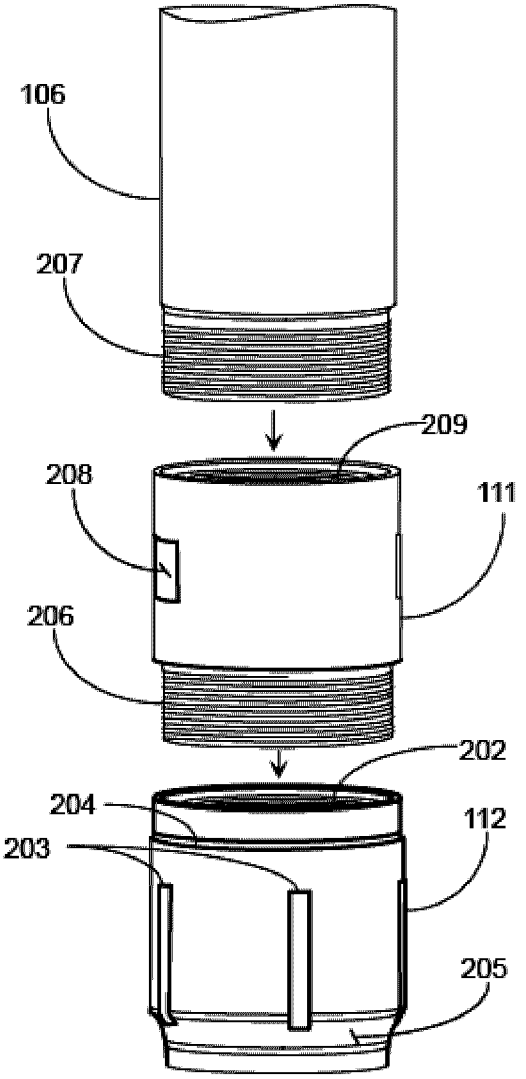


Fig. 2B

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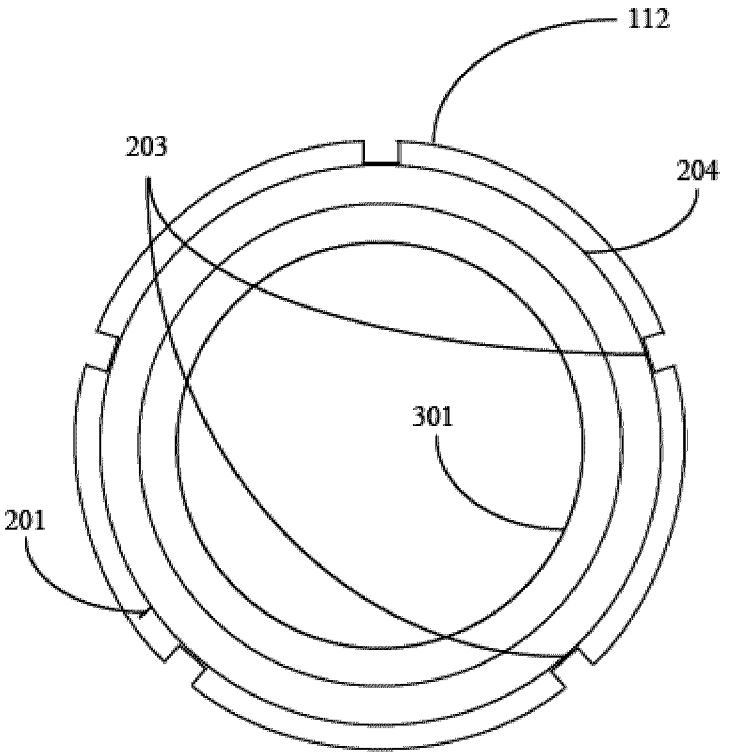


Fig. 3

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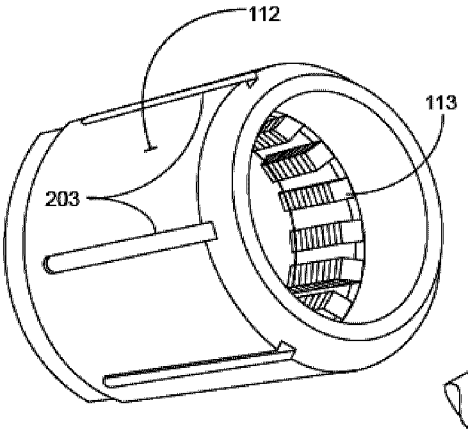


Fig. 4

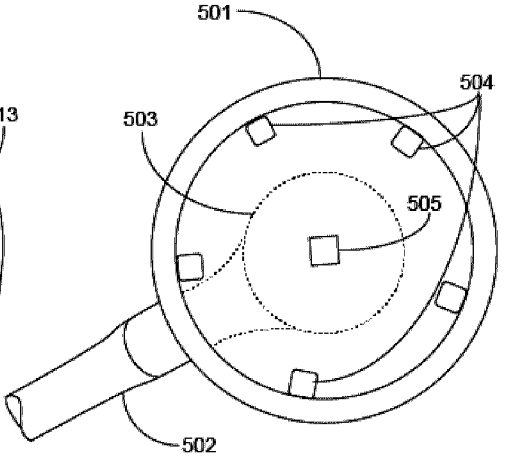


Fig. 5

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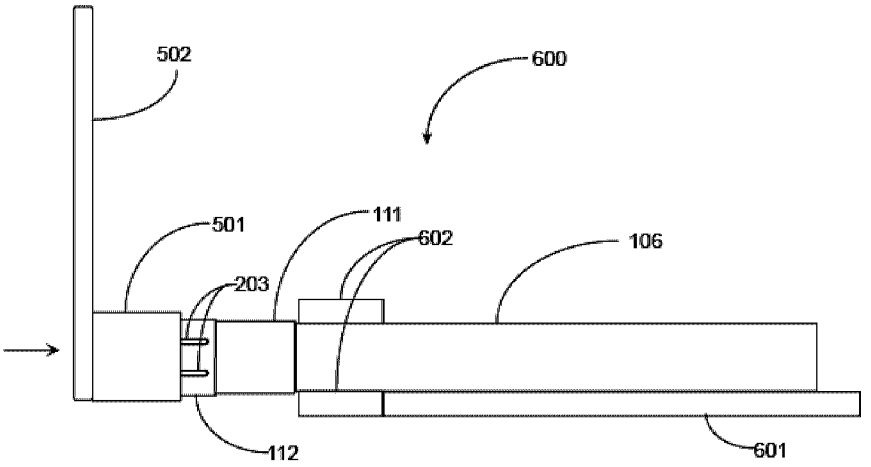


Fig. 6

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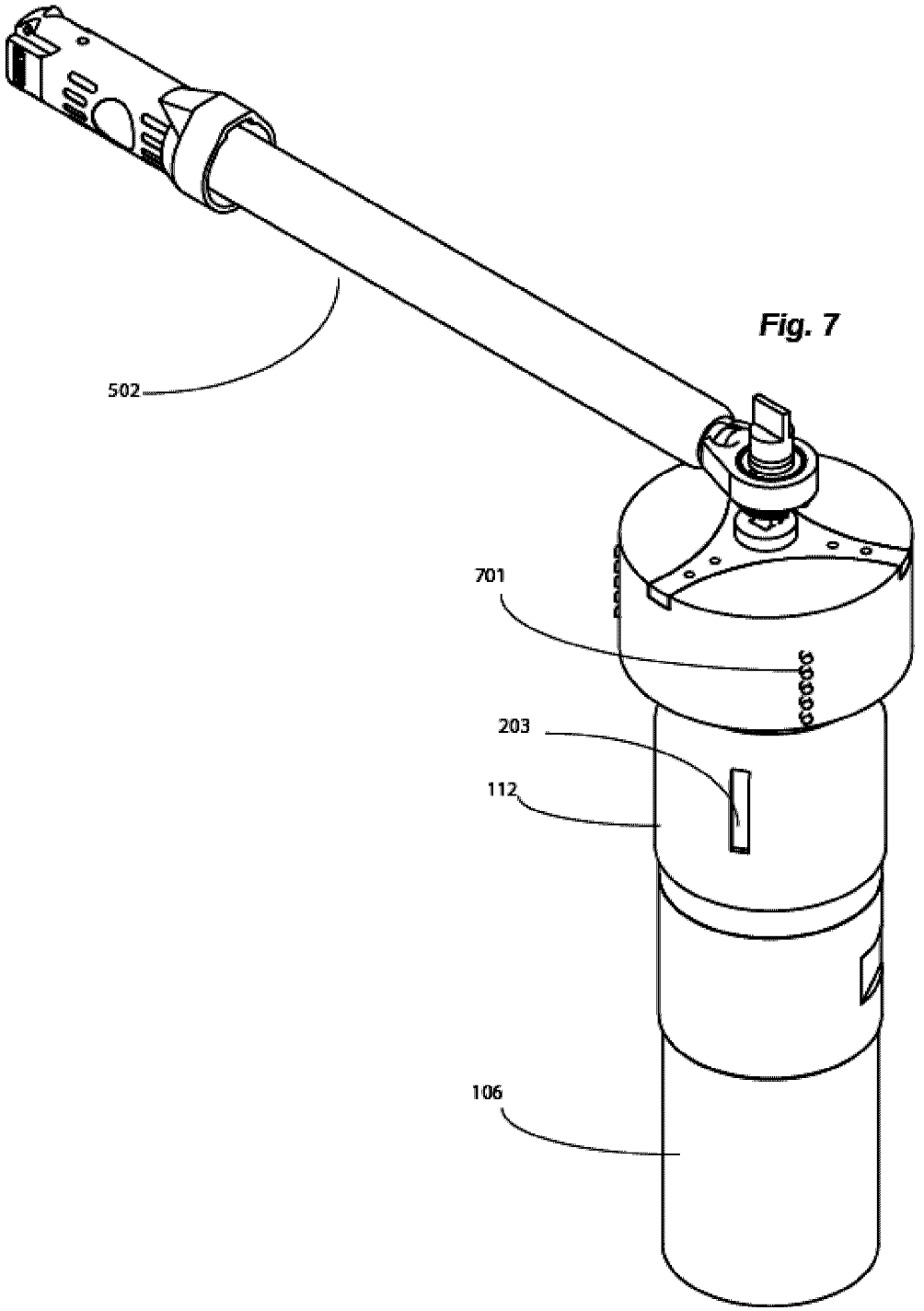
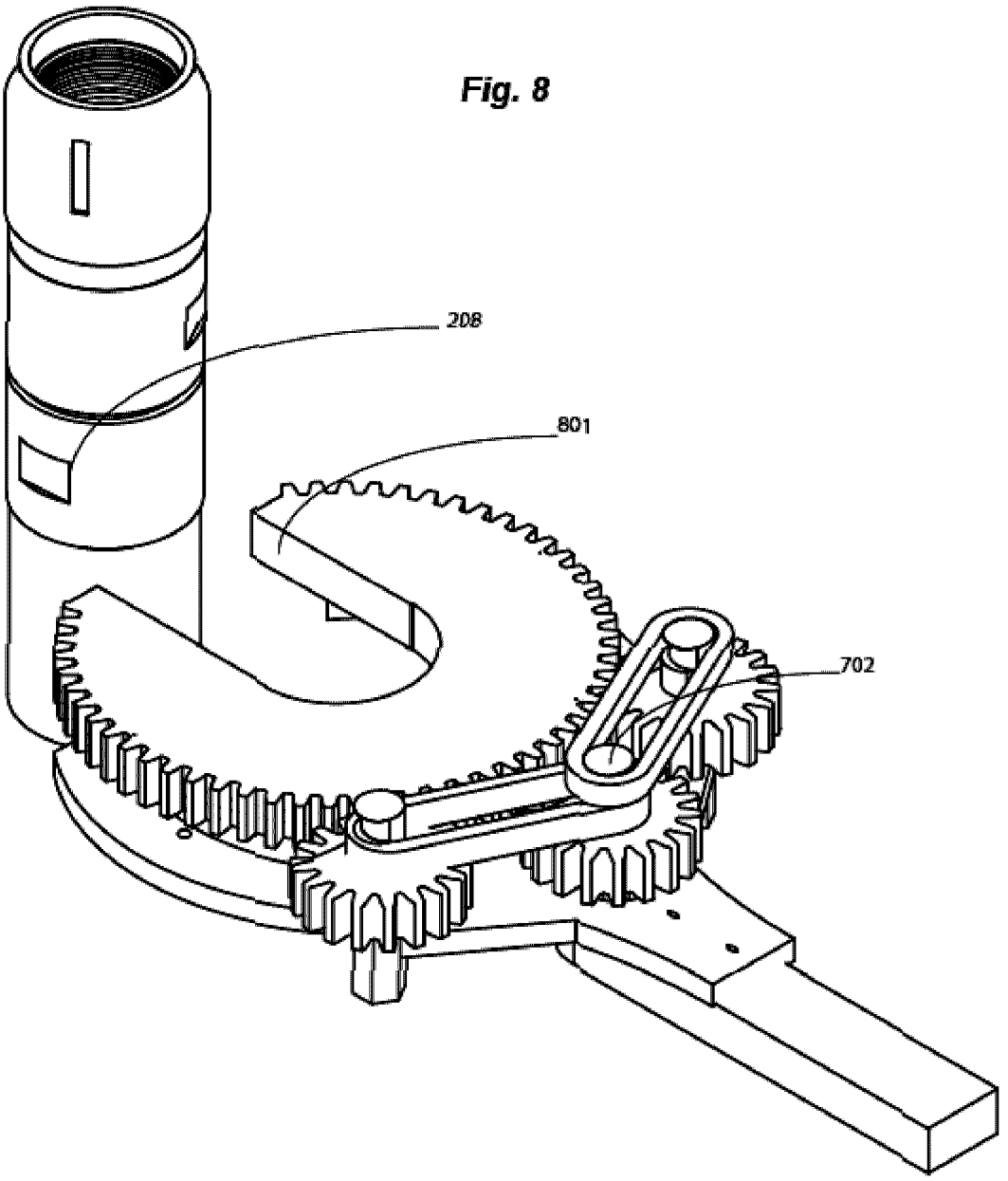


Fig. 7

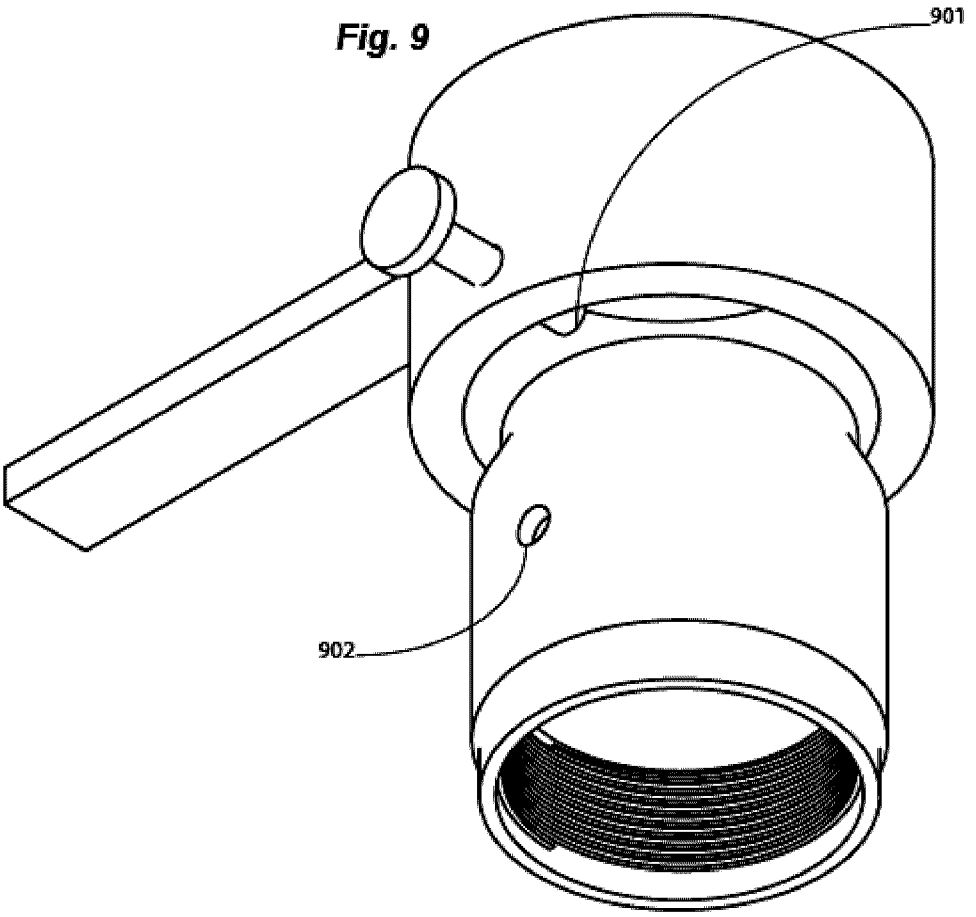
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Fig. 8



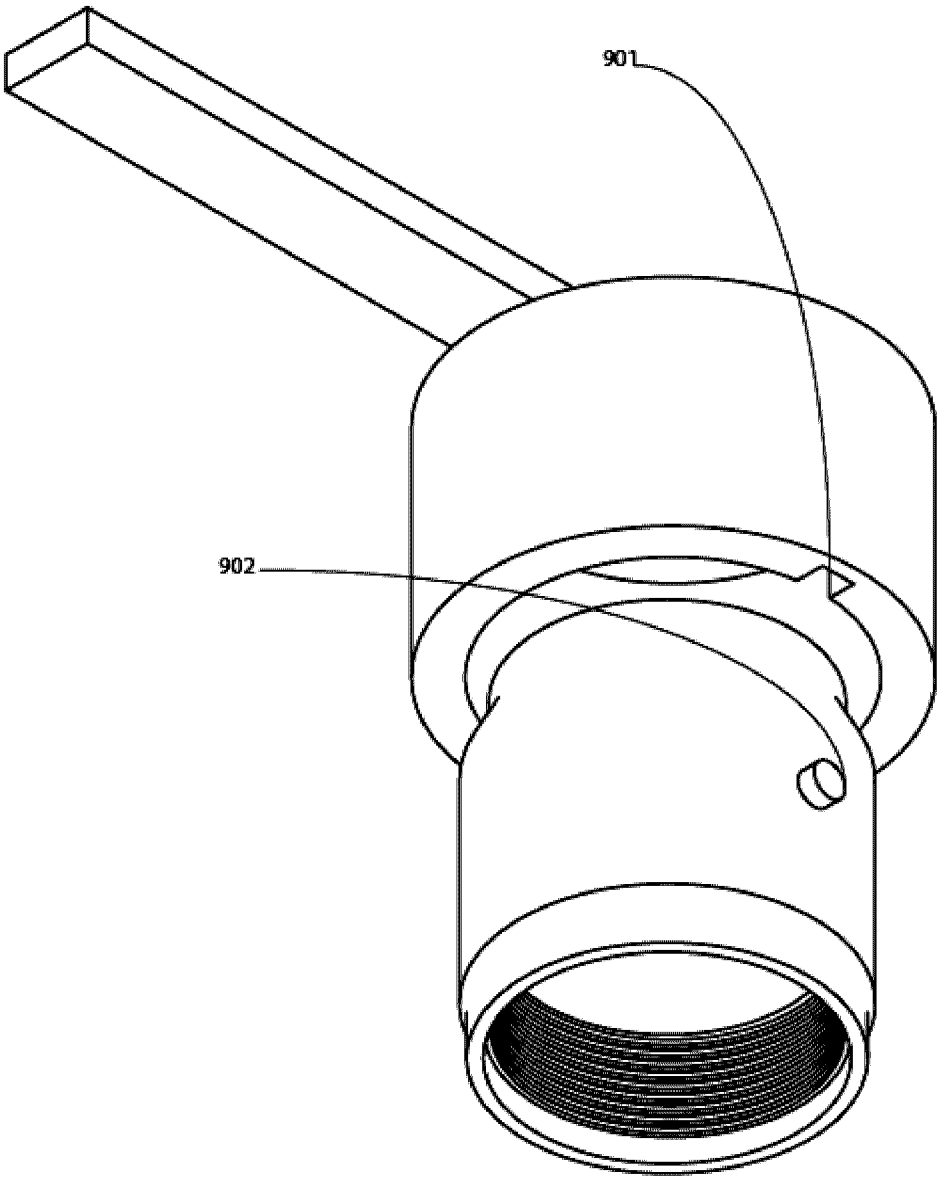
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Fig. 9



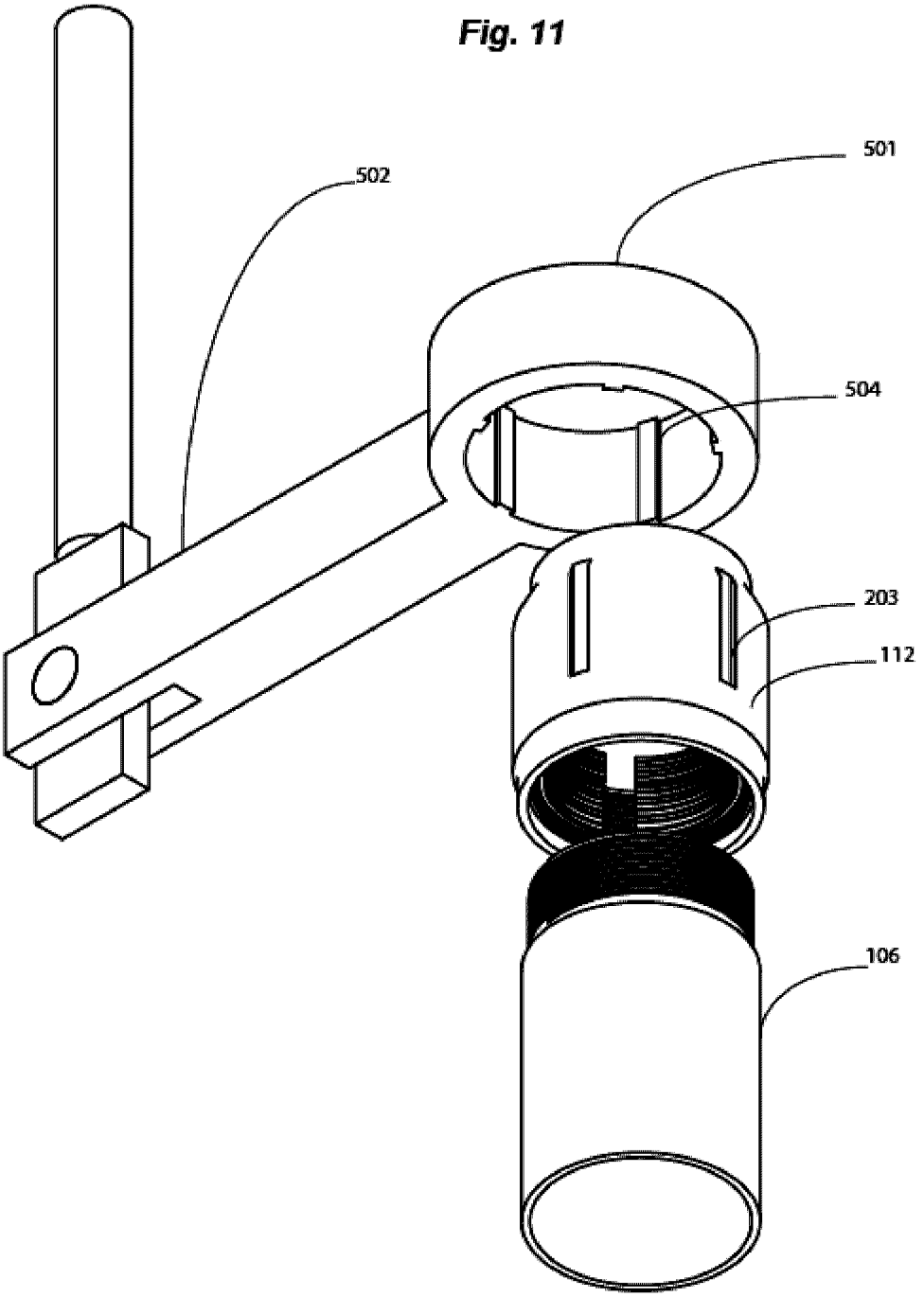
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Fig. 10

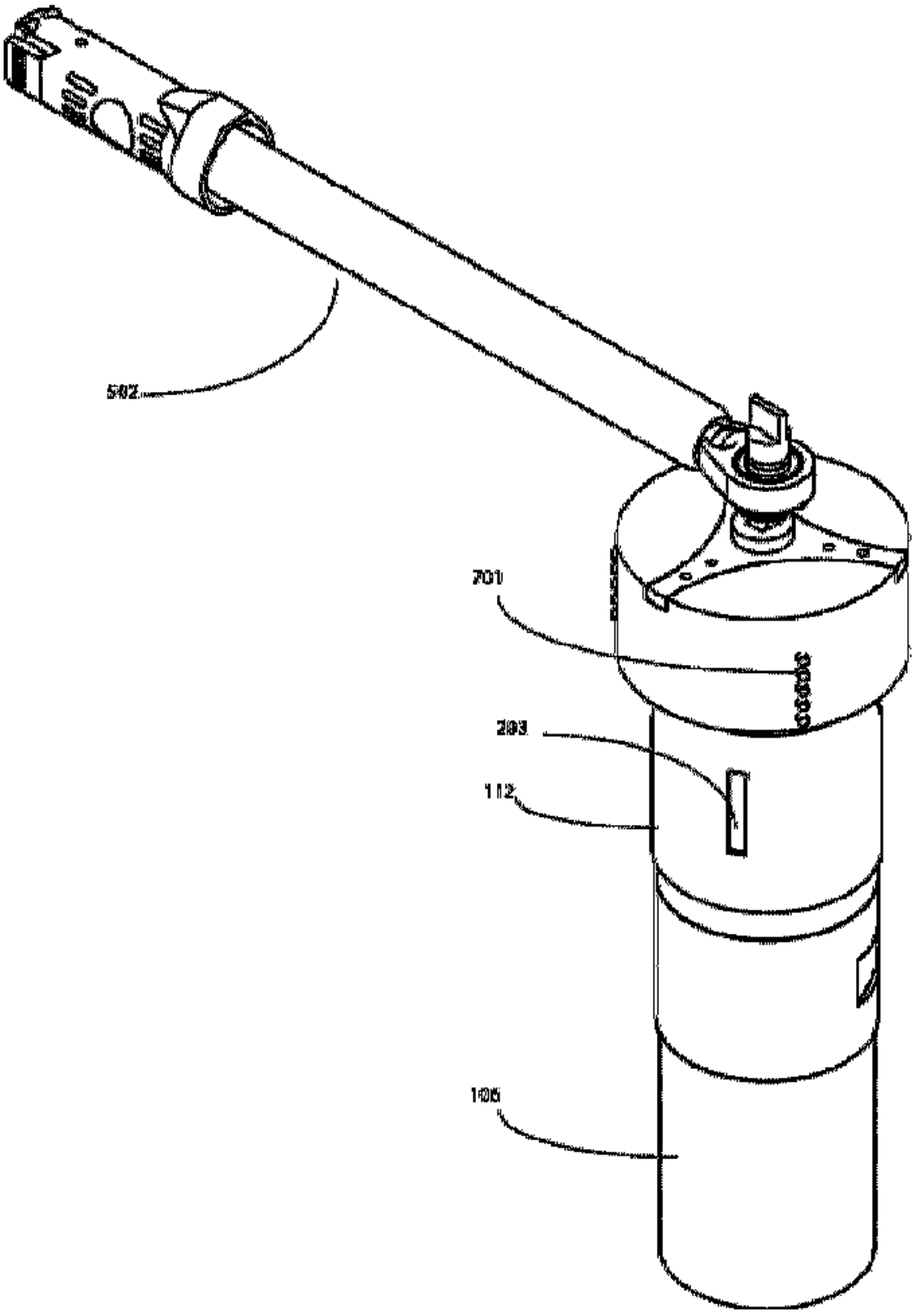


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Fig. 11



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