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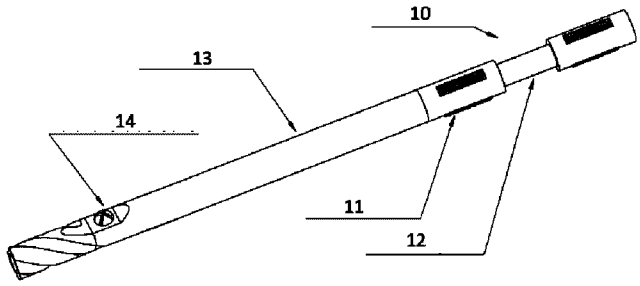
(54) Title **Milling tool with self driven active side cutters**

(56) References Cited:
US 8789624 B2
WO 2014/134736 A1
NO 333485 B
US 2012/0085539 A1

(57) Abstract

An essentially cylindrical tubular milling tool for milling wellbore sidewalls, where the cylindrical tubular milling tool at least comprises: one or more side cutters arranged on the outer periphery of the cylindrical tubular milling tool body, where the side cutters are driven by driving means independent of any driving means of the independent of the cylindrical tubular milling tool body.



Description

Technical Field

[0001] The invention relates to the tools and method for mill out grooves or mill out section of a steel tubular. The invention relates to tools used in oil, gas and deep water wells, mining and underground operations, particularly tubing and casing in the oil and gas wells. In particular, it is disclosed a milling /cutting tool and moving tractor integrated in a drill string or wireline for tubular section milling or making grooves in the tubular inside the oil and gas wells. Any producing wells should be plugged after ending the lifetime. Mill out partially (grooves) or a complete section of the inner tubular inside the wells may be needed for plug and abandonment of a well. The present invention is focused on the method and the tool for more efficient casing section milling.

Background Art

[0002] Numerous attempts have been made to provide proper tools for tubular section milling particularly in the oil wells. Different milling tools with expandable cutter are developed to mill out the steel casing. These tools have two operating states, a closed or collapsed state that enables them to pass through the narrow section of the tubular and an expanded state where one or more arms with cutters extend radially outward from the tool body. When the reamer rotates, the cutting elements on the extended arms mill the sidewalls. US Patents 8839864; 7448446; 7377328; 5201817; 6679328; 4589504; 5368114; 5060738; 4431065 and European patent 0266864 are examples of expandable milling tools with passive cutters. Moreover, it is known from US 2004/0134687 A1 to use an expandable reamer apparatus and methods for reaming a borehole, wherein a laterally movable blade carried by a tubular body may be selectively positioned at an inward position and an expanded position. The movable blade, held inwardly by blade-biasing elements, may be forced outwardly by drilling fluid selectively allowed to communicate therewith by way of an actuation sleeve disposed within the tubular body. US Patent 6378632 B1 discloses an underreamer that opens a borehole below a

restriction that is larger than the restriction itself. The underreamer includes cutters that engage the formation by traversing outward and upward. A piston built into each cutter support supplies the force pushing the cutters to the extended position. Pressure acting on these pistons comes from the pressure differential between the annulus and drill string during circulation of drilling fluid.

[0003] It is also known in prior art that roller side cutters are used instead of the solid cutter blades to mill and enlarge a wellbore. US Patents 6378632; 3917011; 2122763; 2,260366; 3306381; 3627068; 3907048; 4182425; 4398610; 4036314 are examples of expandable milling tools with passive rollers surrounded by abrasives. GB 1208127 relates to well reamers and more particularly to well reamers having a single-roller-cutter used for enlarging well bores. Other examples of reamers can be found in WO 02/064939 A1, US Patent 6378632 B1 and US 2009/0294173 A1. In WO2014/134736 A1 it is disclosed a downhole mud motor formed of plural housings containing at least a drive section and a transmission section. At least a housing of the plural housings has a longitudinal axis and incorporates a reaming section with one or more rotary reamers. Each of the one or more rotary reamers is mounted in a respective pocket for rotation about a transverse axis relative to the longitudinal axis of the housing. US2012085539 A1 discloses a well tool with anchoring means.

[0004] All of the mentioned documents discloses tools for removing the casing section of the wellbores by milling out sections with expandable side cutters. However, mill out the steel and enlarge the tubular diameter with expandable cutting blades is time consuming and associated with increased drill string rotary torque and vibration. In addition, milling out the steel tubular produces long shavings of steel chips that are difficult to clean out of the well.

[0005] A different tool with expandable rotary side cutters for enlarging a wellbore is presented in US patent 8789624. This tool employs active rotational cutters instead of passive blades and roller cutters for wellbore enlargement. Use of the active rotary cutters is claimed to be favourable

with respect to the torque and produce smaller size of steel cuttings that enables to tubular section milling more efficiently.

[0006] According to the present invention, it is disclosed a new concept and tool for casing section milling or making grooves in casing sections.

Disclosure of Invention

[0007] In the present invention, a new concept and the tool for mill out grooves or mill out section of a tubular with side rotational cutters is presented. Employing self-driven rotational side cutters instead of passive blade and roller cutters for milling steel tubular downhole in a well is the focused area according to the present invention. Use of the active rotary cutters is favourable with respect to the torsional vibration and torque and there by increases the milling efficiency of the casing section milling. Another benefit of the present invention is the reduced size of the produced steel chips during milling compared to the traditional tools with passive cutters. This facilitates transportation, cleaning and removing the steel chips out from the wellbore. The tool according to the present invention can be used to mill out tubular in a controlled orientation. This enables to mill out windows in a steel tubular of a wellbore that will be needed for side-track. In addition, the tool in present invention enables to mill out a groove inside the sidewalls. The tool can make the groove in different size and geometry for example axial, radial or helical grooves. According to one embodiment of the invention, the milling tool can create at least one axial groove inside the tubular sidewalls, while the tool housing are moved axially inside the wellbore.

[0008] The object of the invention is met by a milling tool that comprises at least one or more self-driven side cutters arranged along a longitudinal axis of a drill string in a milling housing, where the side cutters are adapted to be rotated independent of the tool housing and independent of the tubular. According to one embodiment of the invention, the cutting tool is specified in that the side cutters are adapted to be rotated by individual driving means. The driving means may according to one aspect of this embodiment use hydraulic energy of the drilling fluids or surface electrical energy transferred through the cable. According to one embodiment of the

invention, the cutting tool is specified in that the driven side cutters can have dome shape or cylindrical shape surrounded by abrasive cutter elements.

[0009] According to one embodiment of the invention, the tool housing is adapted to move slowly radially or axially relative to the ground tubular. Based on this embodiment, the tool housing can be moved by an integrated moving tractor or be pulled by wire cable or drill string. The moving tractor may include at least two set of anchoring pads and can move with a reciprocating mechanism.

[0010] The cutting tool may be designed with the self-driven rotational side cutter as a chain surrounded by abrasive cutter elements. The side chain cutters can be rotated around two axes. The driving means can be located on the two axes or in between the two axes.

[0011] The housing may include at least one actuator for actuating the at least one self-driven mill, in particular to be able to retract in a milling position. The actuating mechanism may according to one aspect of this embodiment comprise one of drilling mud pressure or mechanical means.

[0012] The cutting tool may be specified in that the self-driven rotational side cutters or the chain cutters, extends radially outward from the body of the tool body by means of an actuating system. The rotational side cutters extends radially outward from the body of the tool housing to a greater extent than the tubular inner diameter and thereby dig into the tubular sidewalls and remove the steel material in a milling process.

[0013] The cutting tool may be specified in that the self-driven rotational side cutters or the chain cutters are fixed in the tool body. The rotational side cutters or the chain cutters can be rotated without protruding out of the reamer housing. It might be another mechanical means that expands radially out of the tool housing in a radial orientation that is different from the side cutters. The mechanical means that protrudes out of the tool housing toward the tubular sidewalls may therefore bring the tool housing in an eccentric position relative to the tubular/wellbore longitude axes when the protruding mechanical means is pushing against the tubular/wellbore wall. In the eccentric position, the self-driven side cutters

will be pushed toward the sidewalls and therefore dig into the tubular/wellbore sidewalls. The expandable protruding mechanical means are operated by an actuating mechanism that may among others use hydraulic energy of the drilling fluids or surface electrical energy transferred through the cable.

[0014] The cutting tool may be pulled by means like a wireline or a drill string from inside the tubular or a moving tractor in one end may provide an axial movement. The tractor may consists of several anchoring means of side arms/pads which they can become in an active position expand radially out of the tool body and anchor to the tubular side walls and they can retract to the neutral position. The tractor may also consist of at least two set of anchoring means that are located in different axial position. It may be at least one axial push pull cylinder between the anchoring means that can provide an axial movement between at least two set of the anchoring means when one of the anchoring means is in active position and the other one is in neutral position.

Brief Description of Drawings

[0015] To make the invention readily understandable it will now be described with reference to the drawings in which,

[0016] Figure 1 shows direction and axis of the rotations in the milling tool body with rotational side cones,

[0017] FIG. 2 shows a 3D schematic view of the milling tool with single active rotational side cutter connected to the tractor moving system,

[0018] FIG. 3 shows a schematic view of the milling tool with single dome shape active rotational side cutter,

[0019] FIG. 4 shows a schematic view of the cross section of milling tool inside a well casing with expand able rotational side cutter in neutral and working position,

[0020] FIG. 5 shows a schematic view of the milling tool with single dome shape active rotational side cutter with the eccentric arm in the opposite orientation of the side cutter,

[0021] FIG. 6 shows a schematic view of the cross section of milling tool inside a well casing with non-expandable rotational side cutter and eccentric arms, in neutral and working position,

[0022] FIG. 7 shows a schematic view of the milling tool with multiple dome shape rotational side cutters in straight arrangement,

[0023] FIG. 8 shows a schematic view of the milling tool with multiple dome shape rotational side cutters in helical arrangement,

[0024] FIG. 9 shows a schematic view of the milling tool with single cylindrical rotating side cutter with option of eccentric arms in the opposite orientation,

[0025] FIG. 10 shows a schematic view of the milling tool with multiple cylindrical rotating side cutters in straight arrangement with option of eccentric arms in the opposite orientation,

[0026] FIG. 11 shows a schematic view of the milling tool with multiple cylindrical rotating side cutters in helical arrangement,

[0027] FIG. 12 shows a 3D schematic view of the milling tool with a straight rotating chain surrounded with abrasive cutters,

[0028] FIG. 13 shows a schematic view of the milling tool with a straight rotating chain surrounded by abrasive cutters with option of eccentric arms in the opposite orientation,

[0029] FIG. 14 shows a schematic view of the milling tool with a helical rotating chain surrounded by abrasive cutters.

[0030] FIG. 15 shows a rotational side cutter blade of a non-centric type,

[0031] FIG. 16 shows the rotational side cutter of figure 15 implemented into a milling tool,

[0032] FIG. 17 shows an example of a rotational dome shaped side cutter of a centric type implemented into a milling tool,

[0033] Fig. 18 shows a principle of the driving means for a rotational side cutter, and

[0034] Fig. 19 shows a schematic of the cylindrical tubular milling tool body including a puling tractor,

[0035] Fig. 20 shows another schematic view of the cylindrical tubular milling tool body including a puling tractor, and

[0036] Fig. 21 shows a view of a pulling tractor.

Detailed description of the invention

[0037] The invention will now be described with support from the drawings in which identical reference numbers indicates similar features. The drawings are included for illustrative purposes to make the principle of the invention readily understandable; it shall be appreciated that the person skilled in the art will realize other embodiments than those illustrated by the drawings.

[0038] In the following, the following definition applies; cutters shall be understood as any cutting tools arranged along a cylindrical tubular milling tool (drill string/reamer) behind a drill bit with the purpose of milling holes in walls/tubular walls. Side cutters and cones are used interchangeably and shall be included in the definition of cutters.

[0039] Moreover in the following the wording reamer house / drill string / milling tool and cylindrical tubular milling tool is used interchangeably for a tool according to the present invention which is adapted to mill out material from tubular walls / bore hole walls.

[0040] The basic idea behind the invention is to provide a milling tool which comprises one or more cutters, where at least one of the cutters are rotated by a means different than that of the tool housing, i.e. independent of a drill string /reamer housing or cylindrical tubular milling tool.

[0041] Firstly, a general embodiment utilizing self-powered cutters will be described; thereafter, exemplary embodiments will be disclosed.

[0042] The new milling tool has a cylindrical housing. It consists of at least one rotational cone on the side of the tool housing, approximately vertical or vertical to the axis of the borehole. The side cones can be rotated by using hydraulic driven/mud motor system placed inside the main housing. However many other means of driving systems can be utilised, it is the individualisation of powering the cones/cutters that is important. An internal hydraulic driving system can be placed axial to the side cones or axial to the direction of the milling tool and to rotate the side cones by using a gear/transmission system or by direct drive. The driving means can be electric motors with gear transmission drive or by direct drive.

[0043] Several alternative designs of the rotational side cutters are disclosed, each design can be combined with two "families". The first family includes expandable side cutters in a drill string which provides for a concentric or approximately concentric drill string while the cutters mills out the side walls of a tubular or bore hole (fig. 4), the second family have fixed side cutters the side cutters are pushed against the side walls by at least one protruding arm extending out from the drill string / reamer house body. This second family provides an eccentric solution as the extending arms pushes the milling tool away from the sidewalls thereby pushing the at least one side cutter against the wall (see fig. 6). The extending arms are hereinafter designated "pushing arms".

a) A first design of a side cutter includes at least one rotational side cutter with a dome design, fig 2 – 8.
b) A second design of a side cutter includes at least one cylindrical rotational side mill hereafter named a grinder wheel. This cylindrical side mill resembles that of a grinding wheel of a bench grinder. The rotational grinder wheel has its axis of rotation normal to or substantially normal to the longitudinal of the milling tool body (see fig. 9 – 11). The outer radii of the grinder wheel is provided with grinding means.
c) A third design of a side cutter is of a chain saw type. At least one rotary chain mill is protruding out of the body of a milling tool at least while being operative, ref fig. 12 – 14.
d) A fourth alternative design of the side cones have special non-centric design. The cones with non-circular cross section will be rotated without extending out of body of the reamer by mechanical, hydraulic and even electric mechanisms, ref. figs 15 and 16.
e) Figure 17 shows an example of a rotational side cutter of centric type in a retracted and expanded position.

[0044] It shall be appreciated that all side cutter designs can be combined with at least one pushing arm or all of the side cutter designs can be of an expandable type, i.e. the side cutter has a passive retracted state and an

active milling state where the side cutter protrudes out from the milling tool housing.

[0045] In all alternative designs covering rotational side cutters, the cutting elements mounted on the side cones will rotate around the axis of the cone while the axis of the cone itself may rotate with the milling tool body.

[0046] The direction and axis of the rotations of rotational side cutters, i.e. the first to third design is illustrated in Fig. 1, in which a circle 22 perpendicular to the milling tool body circle 21 shows the cutting path of a cutter element while rotating around the side cone axis. Rotation of the milling tool body is shown by the circle 21 and the arrow indicates the tubular axis. It shall be understood that the milling tool body may rotate, hence providing for helical milling or increasing a diameter of a bore hole or tubular, in the event that the milling tool body does not rotate the milling will be axial or substantial axial with that of the longitudinal axis of the milling tool body and the tubular.

[0047] Side cones can be rotated by internal mud motors and thereby use the hydraulic energy of circulating mud. However, drill string mechanical energy or electric motors can also be used for driving the side cutters. FIGS. 18 shows an example of use of internal mud motor(s) including a proper gear transmission system 67, 77 for driving the side cones 62, 72, 73, 74. Any suitable gear type can be utilised. Different gear types such as worm or bevel can be used depending on the tool design. In addition, high torque hydro-motors can also be employed without gear system, the same applies to electric motors.

[0048] Each side cutter has individual driving system and can be operated independent of the other side cutters.

[0049] It has been indicted that the side cutters can be combined with pushing arms or with an expandable arm mechanism that provides for a passive retracted position of the side cutter and an expanded active position of the side cutter.

[0050] In one embodiment the combination of at least on pushing arm and an expandable arm mechanism can be provided, such a combination may

increase the "milling" diameter of the milling tool according to the present invention.

[0051] It shall also be appreciated that the number of side cutters can be one or more and that the side cutters can be arranged in particular patterns on the milling tool body to facilitate milling in particular patterns or widths.

[0052] Figure 7 shows a schematic drawing of a milling tool with multiple dome shaped rotational side cutters in a straight line arrangement. The figure indicates that the embodiment uses pushing arms, however expandable arms for expandable side cutters may also be used, or a combination thereof.

[0053] Figure 8 shows a schematic drawing of a milling tool with multiple dome shaped rotational side cutters in a helical arrangement. The figure indicates that the embodiment uses one or more pushing arms, however expandable arms for expandable side cutters may also be used, or a combination thereof.

[0054] Figure 10 shows a schematic drawing of a milling tool with multiple cylindrical rotating side cutters in a straight line arrangement. The figure indicates that the embodiment uses pushing arms, however expandable arms for expandable side cutters may also be used, or a combination thereof.

[0055] Figure 11 shows a schematic drawing of a milling tool with multiple cylindrical rotating side cutters in a helical arrangement. The figure indicates that the embodiment uses one or more pushing arms, however expandable arms for expandable side cutters may also be used, or a combination thereof.

[0056] Figure 12 and 13 shows a schematic drawing of a milling tool with one rotational straight chain cutter. It shall be understood that several endless chains may be arranged in parallel around the same axis of rotation thereby providing a chain saw with a saw width that is wider than the width of a single chain. In addition, several chain cutters can be individually arranged on the milling tool body. The figures 12 or 13 indicates that the embodiment uses one or more pushing arms, however expandable arms for expandable side cutters may also be used, or a combination thereof.

[0057] Figure 14 shows a schematic drawing of a milling tool with one rotational helical cutter. The figure indicates that the embodiment uses one or more pushing arms, however expandable arms for expandable side cutters may also be used, or a combination thereof. FIG. 17 shows schematic view of a part of a milling tool body with side cutters. The milling tool body 91 has at least one circular dome shaped side cutter 92 adapted to rotate and expand radially outward relative to the tool housing 91 to a greater extent than the borehole diameter shown in left side. The radial extension of the side cones may be provided by drilling mud pressure or by use of other mechanical systems, including electrical powered systems.

[0058] Schematic of a typical non-centric side cutter 32 is shown in Fig. 15. As shown in the figure the side cone 32 according to this fourth design has non-centric shape covered with cutting elements 36.

[0059] Figure 16 indicates a view of a non-centric cone 42 when it starts to rotate on the left, the cutting elements in the non-centric part of the cone will cover a larger diameter than the milling tool body 41. The milling tool body 41 may be a part of a rotary drill string and therefore may rotate around the axis of the borehole. The right side of the fig. 16 indicates a cone in a passive state, it can readily be seen that the cone 42 does not extend beyond the perimeter of the milling tool body 41 itself in this state.

Description of the tractor

[0060] The tractor 10 is the propulsion unit of the cylindrical tubular milling tool; it is shown in detail in figure 21. The tractor comprises two pistons 42, 43 connected with a push pull piston rod 12 there between. The push pull piston rod can move the end piston 42 relative to the near piston 43 and the rest of the cylindrical tubular milling tool in an axial direction.

[0061] Moving forward, that is in the X-direction in figure 21 starts with the near piston 43 and the end piston 42 in a retracted position, that is the distance between them are minimal, the near end piston 43 expands its anchor pads 11 to get into a fixed grip with its surrounding such as the casing. The anchor pads 13 of the end piston 42 is in a retracted position. The next step is that the end piston is moved in the x-direction by the piston rod 12. When the end piston 42 is in a maximum distance from the near

piston 43, the end piston anchor itself to the surrounding walls or casings by expanding its anchor pads 13 radially. Following this step, the near piston 43 retracts its anchor pads 11 and the end piston 42 can pull the near piston 43 with its cylindrical tubular milling tool body in the x-direction thereby causing the complete cylindrical tubular milling tool body to move in the x-direction.

[0062] Table of references

10	Tractor, moving tractor
11	Anchor elements, anchor pad
12	Push pull cylinder
13	Tool body, milling tool body
14	Rotational side cutter
21	Dome shaped rotational side cutter
32	Non-centric side cutter
36	Cutting elements
41	Milling tool body
42	Non-centric cone
51	Eccentric pushing arm
62	Side cones
67	Gear transmission system
72	Side cones
91	Milling tool body
92	Side cutter
93	Cylindrical rotational side mill
121	Rotary chain mill, chain mill
141	Rotary helical chain mill

[0063]

Claims

1. A sidewalls wellbore cylindrical tubular milling tool, where the cylindrical tubular milling tool at least comprises:
    a. one or more self-driven side cutters (14, 21, 32, 42, 62, 93, 121, 141) arranged along a longitudinal axis of the cylindrical tubular milling tool body (13), where the side cutters (14, 21, 32, 42, 62, 93, 121, 141) are driven by driving means independent of the cylindrical tubular milling tool body; and
    c h a r a c t e r i s e d i n that
    b. at least one pushing arm (51) extending radially outward from the cylindrical tubular milling tool body by means of an actuating system.

2. A milling tool according to claim 1, c h a r a c t e r i s e d i n that the rotational side cutters (14, 21, 32, 42, 62, 93, 121, 141) extends radially outward from the cylindrical tubular milling tool body by means of an actuating system.

3. A milling tool according to claim 1and 2, c h a r a c t e r i s e d i n that the side cutters have dome (14, 21), cylindrical (14, 93) or chain shape (14, 121, 141) surrounded by abrasives cutter elements.

4. A milling tool according to claim 2 and 3, c h a r a c t e r i s e d i n that an actuating mechanism is provided by one of; drilling mud pressure, electrical or mechanical means.

5. A milling tool according to any of the claims 2 - 3, c h a r a c t e r i s e d i n that the driving means for direct drive of the side cutters (14, 21, 32, 42, 62, 93, 121, 141) can be any of: a mud motor, a hydraulic motor or an electric motor.

6. A milling tool according to claim 1 and 3, c h a r a c t e r i s e d i n that the cylindrical tubular milling tool body (13) may consist of several side cutters (14, 21, 32, 42, 62, 93, 121, 141) which are arranged in a line parallel to the axis of the tubular/wellbore axis.

7. A milling tool according to claim 1 -5, c h a r a c t e r i s e d i n that the side cutters (14, 21, 32, 42, 62, 93, 121, 141) have different sizes to mill out and making the grooves in the sidewalls stepwise.

8. A milling tool according to claim 1 and 3, c h a r a c t e r i s e d i n that the cylindrical tubular milling tool body (13) may consist of several side cutters (14, 21, 32, 42, 62, 93,141) which are arranged in a helix where the helical axis is parallel to the axis of the cylindrical tubular milling tool body.

9. A milling tool according to claim 1 and 3, c h a r a c t e r i s e d i n that the cylindrical tubular milling tool body (13) consist of one or more moving chains (121, 141) surrounded by abrasive cutters where the one or more chains rotates around two main axis where the axis are perpendicular to the cylindrical tubular milling tool body longitudinal axis and tubular/wellbore axis.

10. A milling tool according to claim 1 and 3, c h a r a c t e r i s e d i n that the cylindrical tubular milling tool body consist of one or more rotational chains (121, 141) surrounded by abrasive cutters where the one or more chains rotates around two main axis where the one or more chains are moving in a helical path relative to the cylindrical tubular milling tool body.

11. A milling tool according to claim 1-11, c h a r a c t e r i s e d i n that a moving tractor system (10) consist of at least two set of anchoring pads (11, 13) and a moving cylinder (12) in the middle for pull or push the cylindrical tubular milling tool body along the longitudinal axis the tubular/wellbore.

12. A milling tool according to claim 12, c h a r a c t e r i s e d i n that the moving tractor system (10) can slowly rotate the milling tool housing while moving along the longitudinal axis of the tubular/wellbore.

13. A milling tool according to claim 1and 12-13, c h a r a c t e r i s e d i n that the self-driven rotational side cutters mounted in the cylindrical tubular milling tool body are adapted to have axial, radial or helical movement relative to the longitudinal axis of the tubular/wellbore.

P a t e n t k r a v

1. Sylindrisk rørfreseverktøy for rørvegger i brønnhull, hvor det sylindriske rørfreseverktøyet i hvert fall omfatter:
   a. ett eller flere selvdrevne sideskjær (14, 21, 32, 42, 62, 93, 121, 141) anordnet langs en lengdeakse til det sylindriske rørfreseverktøyets legeme (13), hvor sideskjærene (14, 21, 32, 42, 62, 93, 121, 141) er drevet av en drivinnretning uavhengig av det sylindriske rørfreseverktøyets legeme; og
   k a r a k t e r i s e r t v e d at
   b. minst én skyvearm (51) blir strukket radialt utover fra det sylindriske rørfreseverktøyets legeme ved hjelp av et aktiveringssystem.

2. Freseverktøy ifølge krav 1, k a r a k t e r i s e r t v e d at de roterbare sideskjærene (14, 21, 32, 42, 62, 93, 121, 141) blir strukket radialt utover fra det sylindriske rørfreseverktøyets legeme ved hjelp av et aktiveringssystem.

3. Freseverktøy ifølge kravene 1 og 2, k a r a k t e r i s e r t v e d at sideskjærene har en kuppelform (14, 21), sylindrisk form (14, 93) eller kjedeform (14, 121, 141) omgitt av slipende skjæreelementer.

4. Freseverktøy ifølge kravene 2 og 3, k a r a k t e r i s e r t v e d at en aktiveringsmekanisme er tilveiebragt av én av: boreslamtrykk, elektriske eller mekaniske innretninger.

5. Freseverktøy ifølge ethvert av kravene 2 - 3, k a r a k t e r i s e r t v e d at drivinnretningen for direkte å drive sideskjærene (14, 21, 32, 42, 62, 93, 121, 141) kan være en hvilken som helst av: en slammotor, en hydraulisk motor eller en elektrisk motor.

6. Freseverktøy ifølge kravene 1 og 3, k a r a k t e r i s e r t v e d at det sylindriske rørfreseverktøyets legeme (13) kan bestå av flere sideskjær (14, 21, 32, 42, 62, 93, 121, 141) som er anordnet langs en linje som er parallell med rørets/brønnhullets akse.

7. Freseverktøy ifølge kravene 1-5, k a r a k t e r i s e r t v e d at sideskjærene (14, 21, 32, 42, 62, 93, 121, 141) har forskjellige størrelser for stegvis å frese ut og danne sporene i sideveggene.

8. Freseverktøy ifølge kravene 1 og 3, k a r a k t e r i s e r t v e d at det sylindriske rørfreseverktøyets legeme (13) kan bestå av flere sideskjær (14, 21, 32, 42, 62, 93,141) som er anordnet i en spiral, hvor spiralaksen er parallell med aksen til legemet til det sylindriske rørfreseverktøyet.

9. Freseverktøy ifølge kravene 1 og 3, k a r a k t e r i s e r t v e d at det sylindriske rørfreseverktøyets legeme (13) består av ett eller flere bevegelige kjeder (121, 141) omgitt av slipeskjær, hvor det ene eller de flere kjedene roterer om to hovedakser, hvor aksene står vinkelrett på det sylindriske rørfreseverktøyets legemes lengdeakse og rørets/brønnhullets akse.

10. Freseverktøy ifølge kravene 1 og 3, k a r a k t e r i s e r t v e d at det sylindriske rørfreseverktøyets legeme består av ett eller flere roterbare kjeder (121, 141) omgitt av slipeskjær, hvor det ene eller de flere kjedene roterer om to hovedakser, hvor det ene eller de flere kjedene beveger seg i en spiralbane i forhold til det sylindriske rørfreseverktøyets legeme.

11. Freseverktøy ifølge kravene 1-11, k a r a k t e r i s e r t v e d at et bevegelig traktorsystem (10) består av minst to sett av ankerblokker (11, 13) og en bevegelig sylinder (12) i midten for å trekke eller skyve det sylindriske rørfreseverktøyets legeme langs rørets/brønnhullets lengdeakse.

12. Freseverktøy ifølge krav 12, k a r a k t e r i s e r t v e d at det bevegelige traktorsystemet (10) er i stand til å rotere freseverktøyhuset langsomt mens det beveger seg langs rørets/brønnhullets lengdeakse.

13. Freseverktøy ifølge krav 1 og 12-13, k a r a k t e r i s e r t v e d at de selvdrevne roterbare sideskjærene anordnet i det sylindriske rørfreseverktøyets legeme er innrettet for aksial, radial eller spiralgående bevegelse i forhold til rørets/brønnhullets lengdeakse.

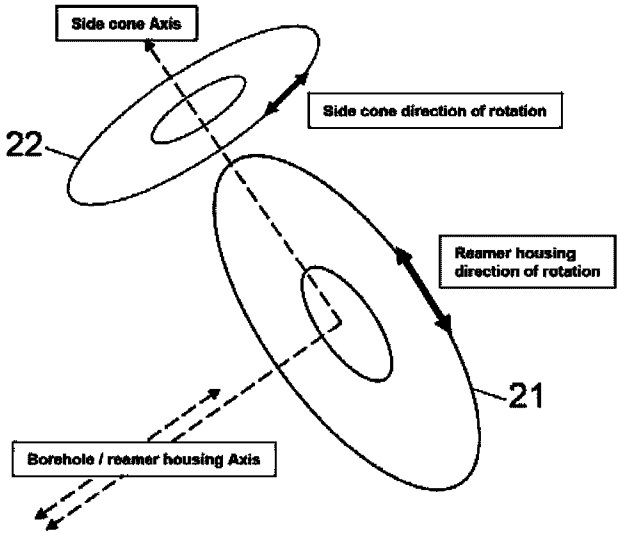


Fig. 1

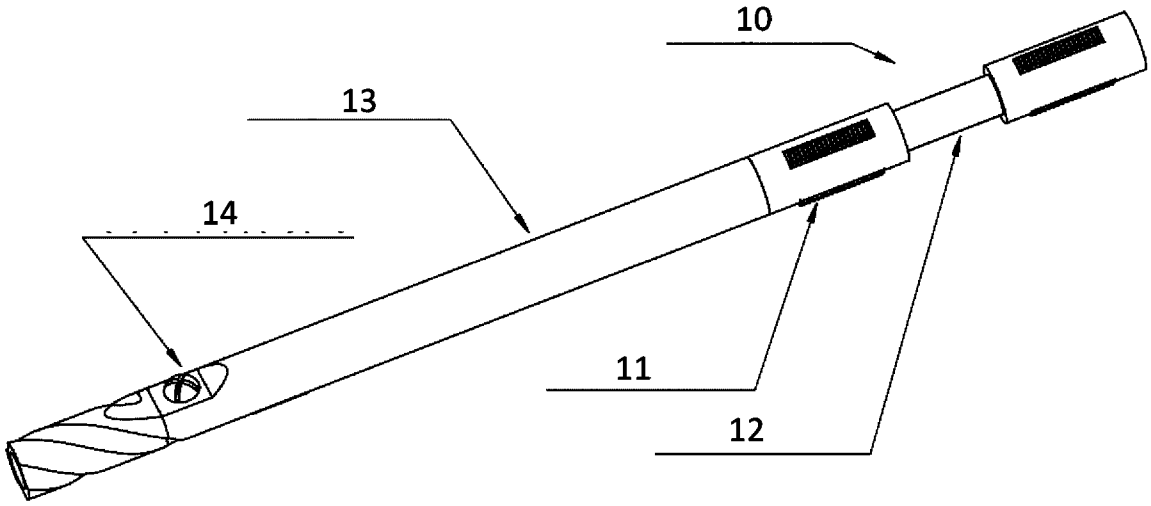


Fig. 2

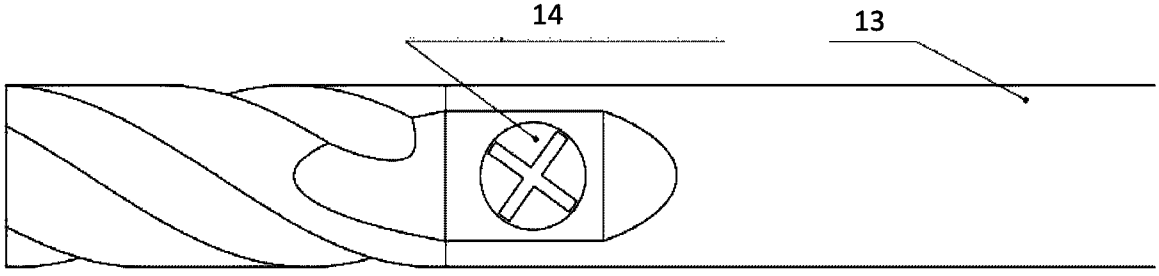


Fig. 3

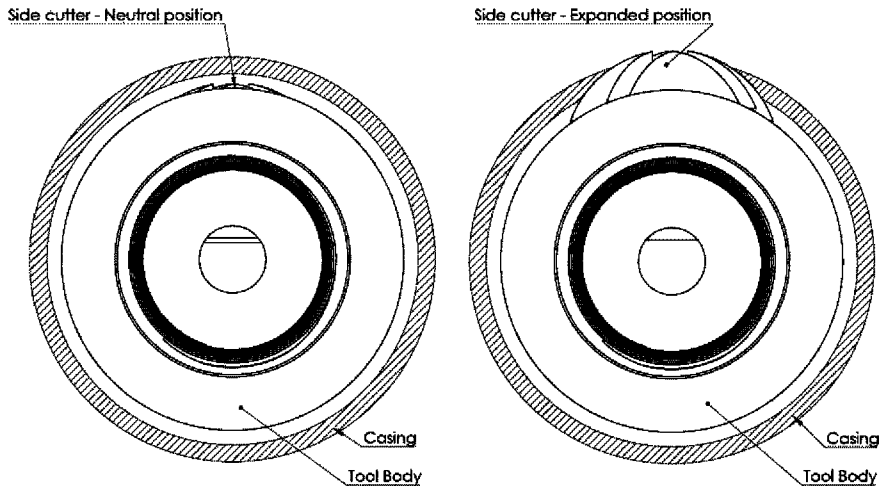


Fig. 4

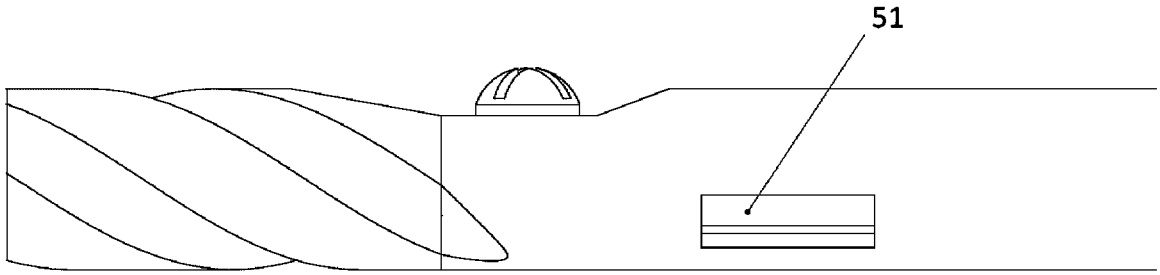


Fig. 5

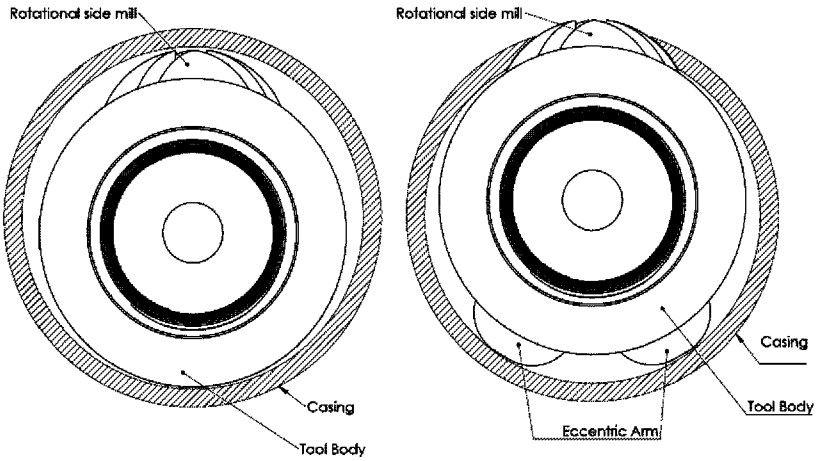


Fig. 6

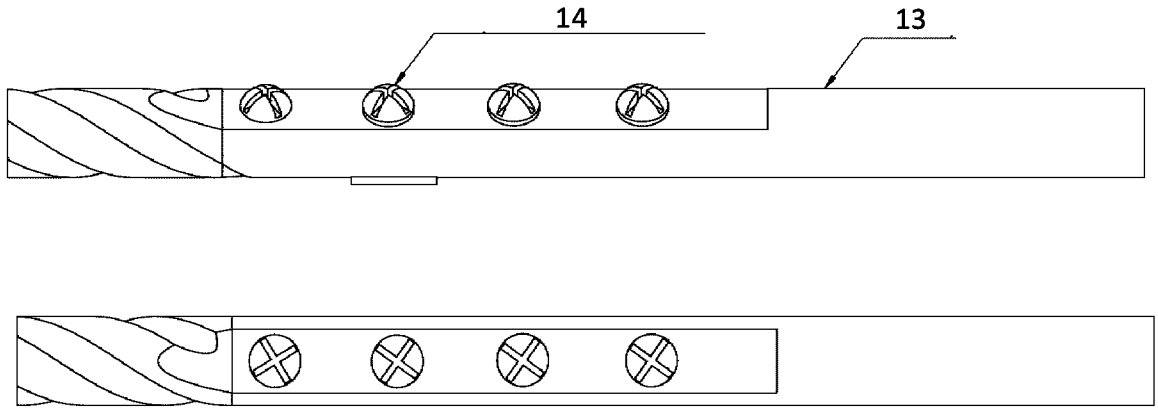


Fig. 7

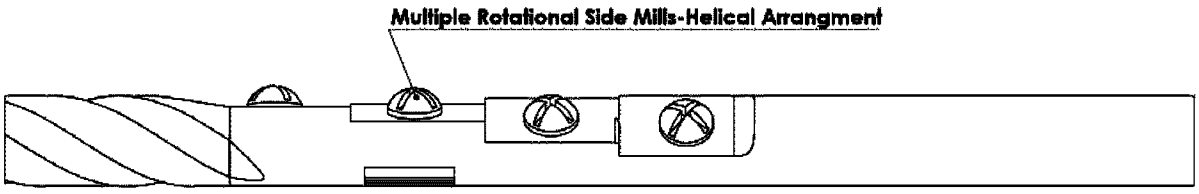


Fig. 8

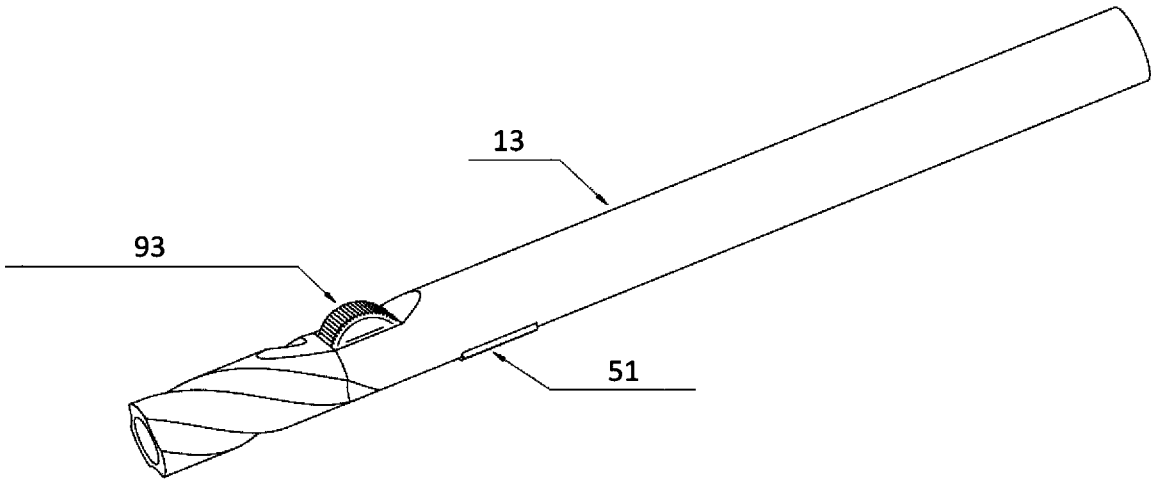


Fig. 9

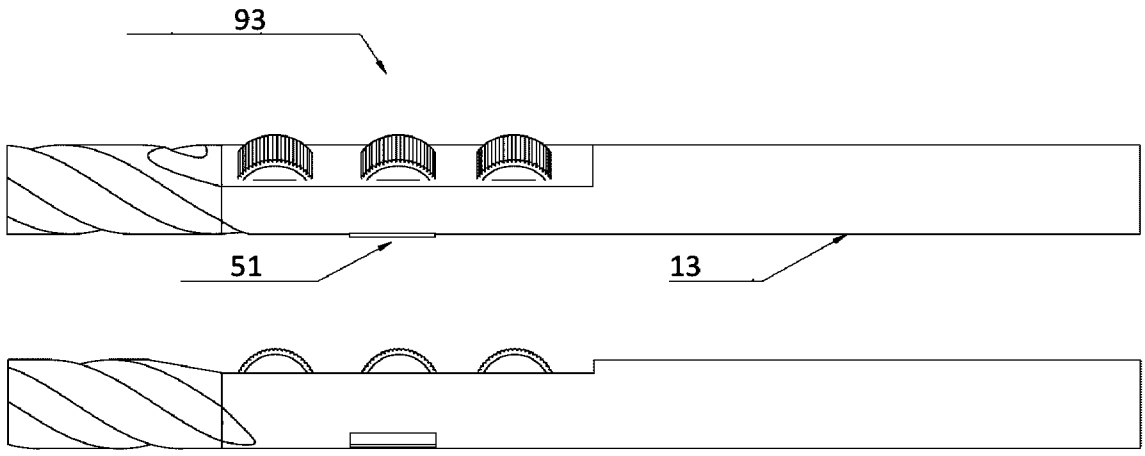


Fig. 10

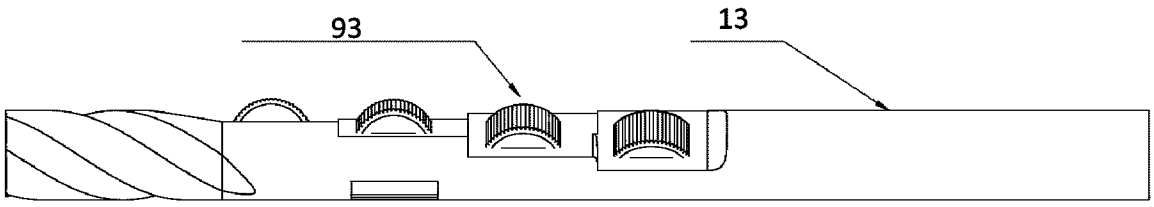


Fig. 11

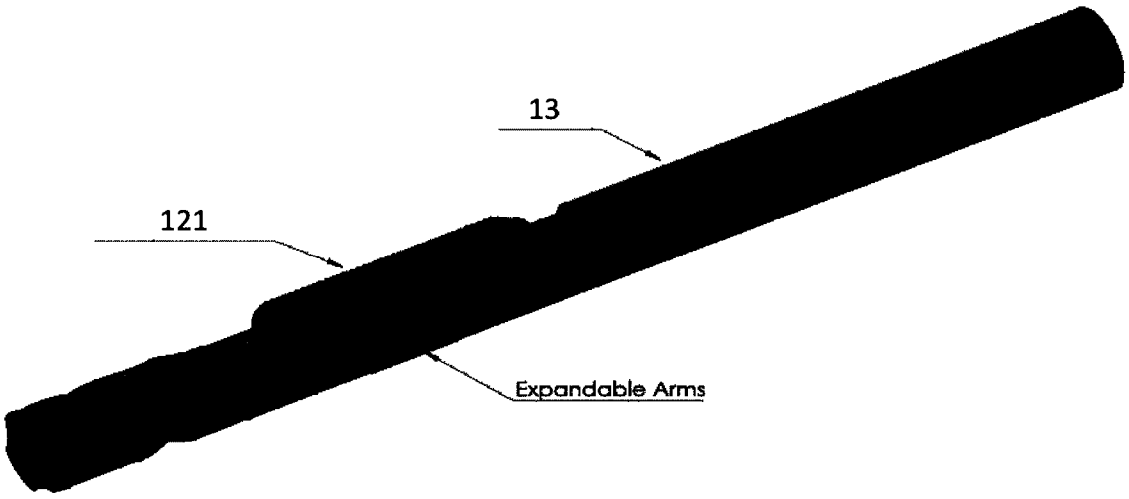


Fig. 12

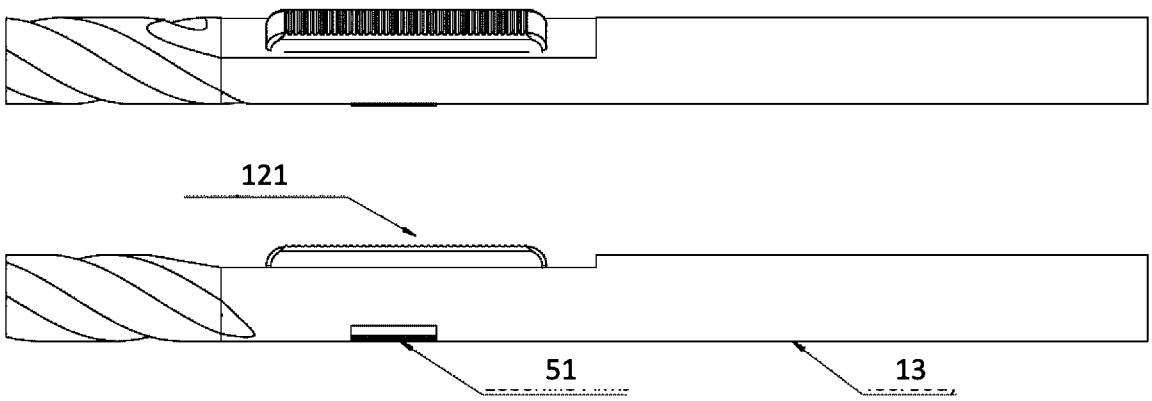


Fig. 13

Fig. 14

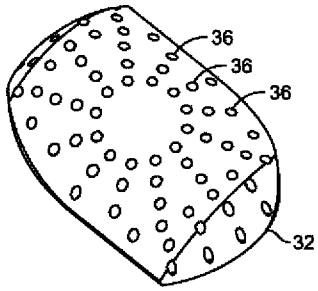


Fig. 15

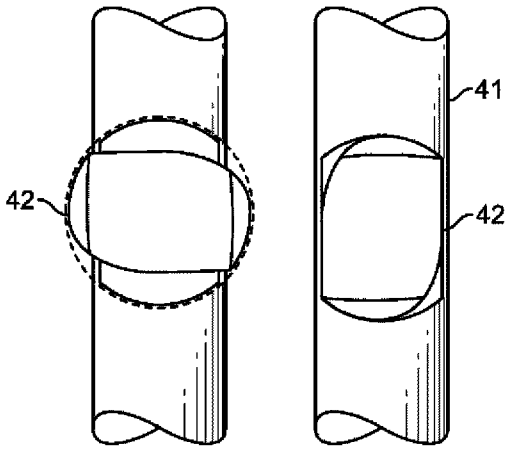


Fig. 16

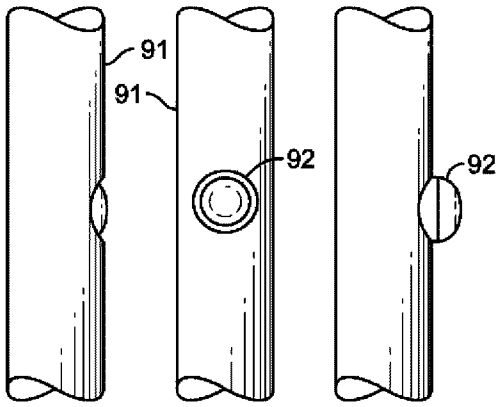


Fig. 17

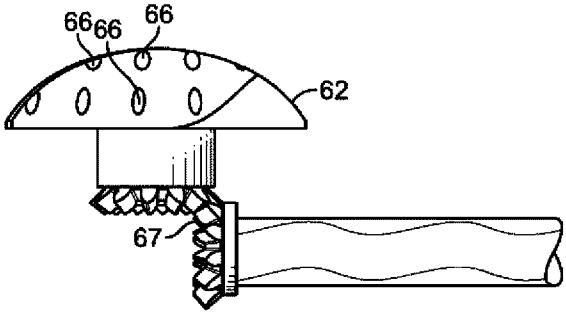


Fig. 18

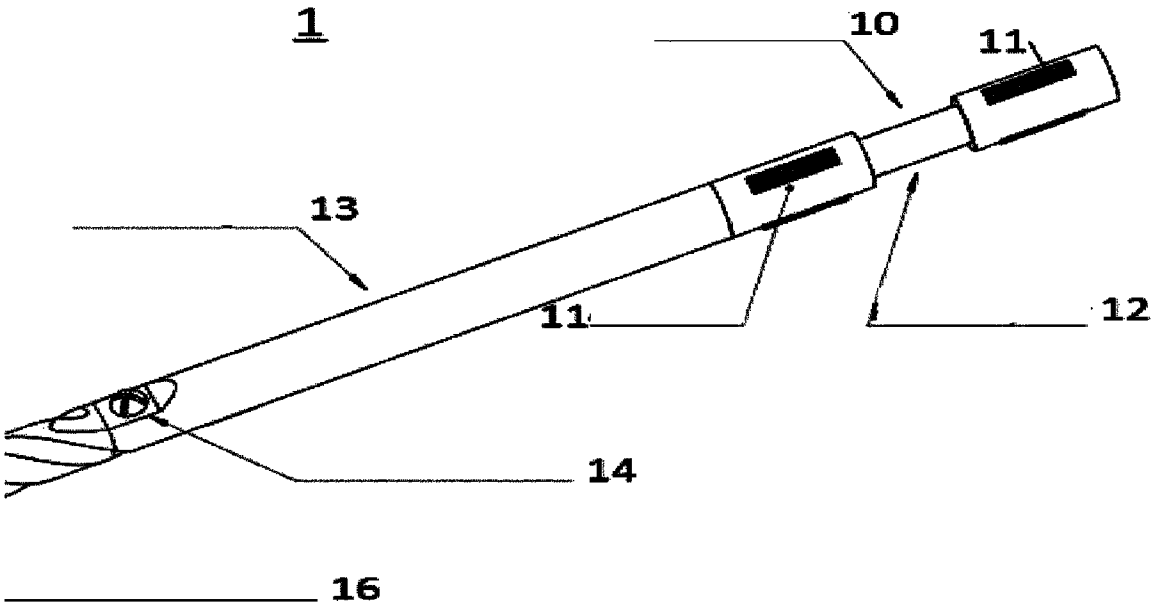


Fig. 19

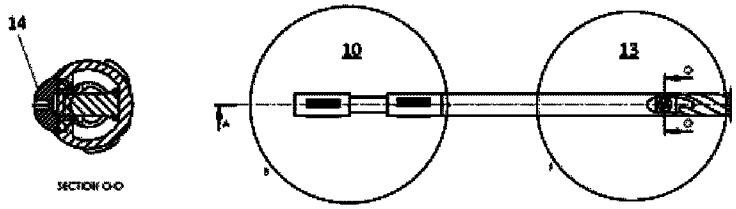


Fig. 20

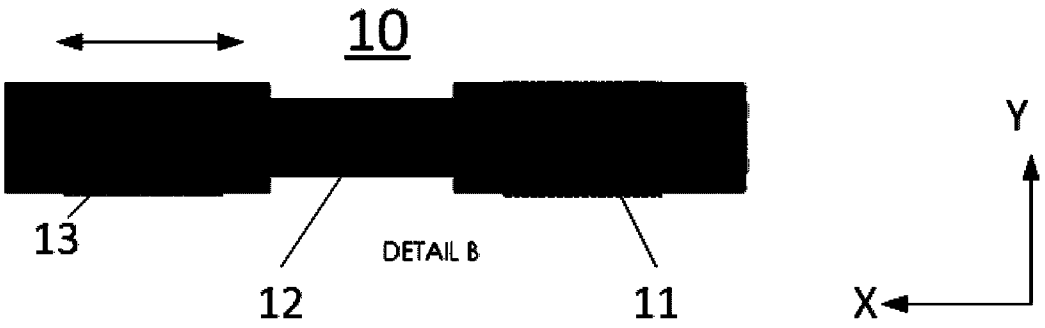


Fig. 21