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(71) Applicants:
- **China Petroleum & Chemical Corporation**
  Beijing 100728 (CN)
- **Sinopec Petroleum Engineering Technology Research**
  Institute Co., Ltd.
  Beijing 102206 (CN)
- **Shelfoil Petroleum Equipment & Services Co., Ltd.**
  Dezhou, Shandong 253000 (CN)

(72) Inventors:
- **HU, Liang**
  Beijing 102206 (CN)
- **RUAN, Chenliang**
  Beijing 102206 (CN)
- **CHEN, Wujun**
  Beijing 102206 (CN)
- **GU, Lei**
  Beijing 102206 (CN)
- **CHENG, Guangming**
  Beijing 102206 (CN)
- **YIN, Huibo**
  Beijing 102206 (CN)
- **CAO, Haitao**
  Beijing 102206 (CN)

(74) Representative: **karo IP**
Patentanwälte PartG mbB
Steinstraße 16-18
40212 Düsseldorf (DE)

(54) MECHANICS-ELECTRONICS-HYDRAULICS INTEGRATED DIRECTIONAL TOOL FOR CONTINUOUS TUBING DRILLING

(57) The present invention proposes a directional tool for coiled tubing drilling, which comprises an electronic control module; a hydraulic driving module, which comprises a motor in signal connection with the electronic control module, an oil bladder unit arranged between the electronic control module and the motor, for storing compensating hydraulic oil for balancing a difference between an internal pressure and an external pressure of the hydraulic driving module, a bidirectional hydraulic pump connected to the motor, and a piston unit comprising a piston housing and a piston, a first liquid cavity and a second liquid cavity in communication with the bidirectional hydraulic pump being formed at both ends of the piston, respectively; and a mechanical transmission module, with both ends thereof connected to the piston and a downhole drilling tool, respectively, wherein the electronic control module is configured to transmit the ground control command to the hydraulic driving module, so that the motor drives the bidirectional hydraulic pump to generate high-pressure oil and low-pressure oil in the first liquid cavity and the second liquid cavity alternately, thus driving the piston to perform axial movement reciprocally, and the mechanical transmission module is configured to convert the axial movement of the piston into a rotational movement, in order to drive the downhole drilling tool to rotate and thus adjust downhole tool face.

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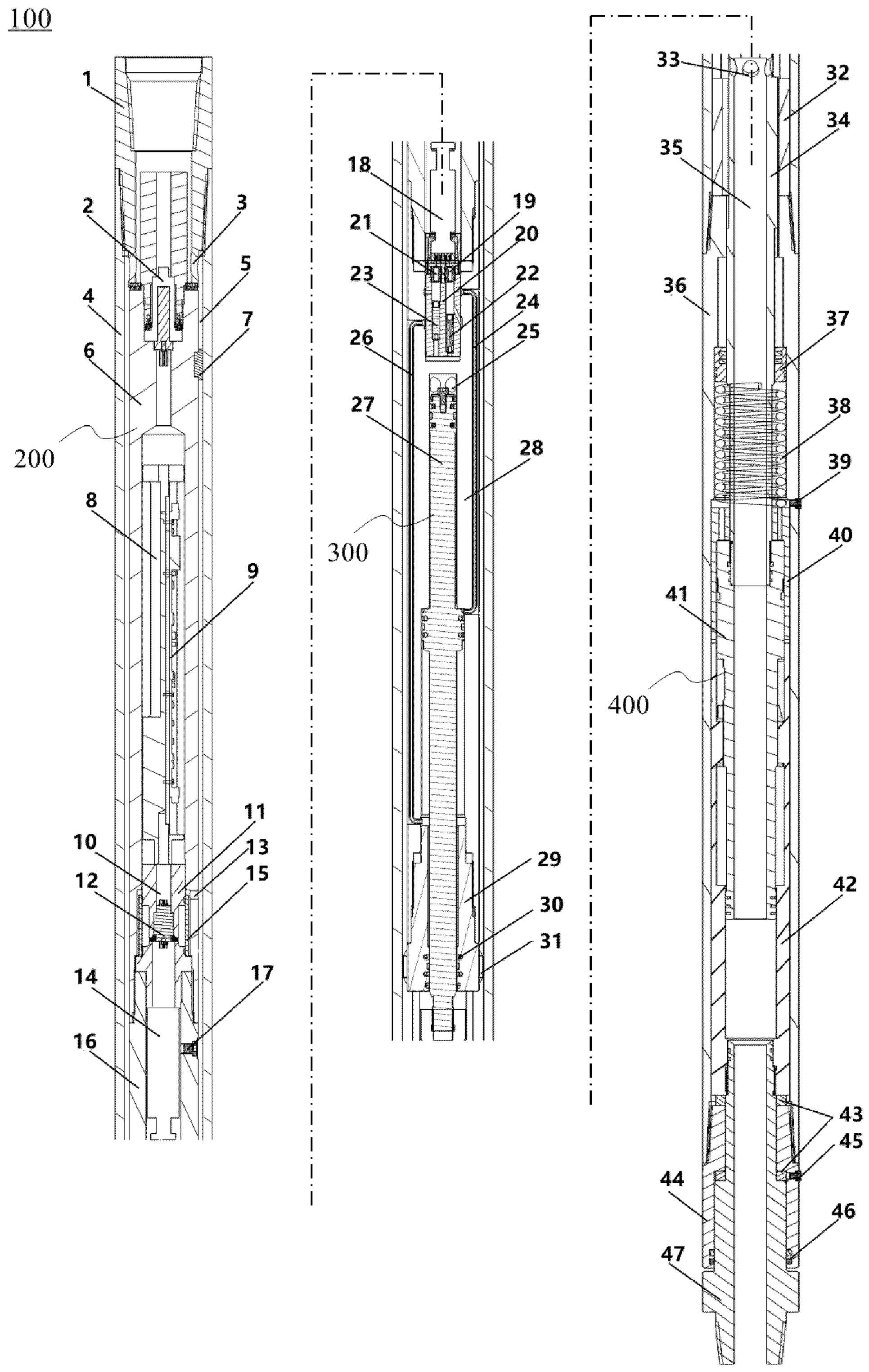
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Fig. 1

Description

Cross Reference of Related Applications

[0001] The present application claims the priority of Chinese patent application No. 202210783518.1 entitled "Mechanics-Electronics-Hydraulics Integrated Directional Tool for Coiled Tubing Drilling" and filed on July 5, 2022, the entire content of which is incorporated herein by reference.

Technical Field

[0002] The present invention relates to the technical field of drilling tools for oil-gas well, and specifically to a mechanics-electronics-hydraulics integrated directional tool for coiled tubing drilling.

Technical Background

[0003] During coiled tubing drilling, the coiled tubing and the bottom hole assembly are non-rotatable due to restriction by coiled tubing running device at the wellhead. Therefore, the bottom hole assembly must be equipped with a specialized directional tool to achieve directional drilling for the coiled tubing. Such a directional tool, which is the core tool in the coiled tubing drilling, determines the technical level of trajectory control during coiled tubing drilling.

[0004] Currently, existing directional tools for coiled tubing drilling at home and abroad can be divided into two types based on driving mode, namely drilling fluid-driven or independent hydraulic-driven directional tools. However, the existing directional tools for adjusting tool face with mechanical structures driven by drilling fluid still have the following disadvantages. For example, they are not applicable for gas or foam drilling, and thus have limited applications. Moreover, the displacement of mud pump needs to be increased during directional drilling, which affects normal drilling parameters.

[0005] The existing directional tools driven by independent hydraulic systems can realize rotational motion through specific mechanical structures, thus achieving adjustment of the downhole tool face. The independent hydraulic system of such directional tool includes two sets of hydraulic assemblies to achieve the piston's reciprocating motion, which result in a complicated structure of the system and affect the reliability thereof. Moreover, a mechanical rotating part of such directional tool adopts a long-screw transmission structure, but the screw angle thereof fails to meet the self-locking condition, thus leading to slipping after rotation. To ensure reliable locking after the screw rotation, it is necessary to provide a specialized locking mechanism or adopt hydraulic lock technology. Meanwhile, each of the output rotation angles of the long-screw transmission corresponds to a respective displacement of the reciprocating motion. The position of the moving nut must be accurately positioned to output definite rotation angles. Hence, a displacement sensor needs to be installed within the confined mechanical fitting space, and corresponding software algorithms need to be designed for control purposes. However, such arrangements will make it difficult to design the tool and ensure the reliability thereof.

[0006] Furthermore, the downhole hydraulic systems are prone to hydraulic oil leakage due to their long-term operation in high-temperature and high-pressure environment, which will have an adverse impact on the accurate operation of directional tools.

Summary of the Invention

[0007] In view of the above technical problems, the present invention aims to propose a mechanics-electronics-hydraulics integrated directional tool for coiled tubing drilling, which can adjust the downhole tool face in real time to meet the directional requirements of coiled tubing drilling. The hydraulic driving module adopts one set of hydraulic assembly to achieve the reciprocating motion of the piston, and can be reliably locked after the mechanical transmission motion is completed, so that the slipping that affects the rotation effect can be prevented. There is no need to arrange an additional self-locking structure or positioning sensor, thus significantly simplifying the structure of the system and improving the reliability thereof.

[0008] Aimed at solving the above technical problems, the present invention proposes a mechanics-electronics-hydraulics integrated directional tool for coiled tubing drilling, which comprises: an electronic control module, for receiving a ground control command; a hydraulic driving module, which comprises a motor in signal connection with the electronic control module, a bidirectional hydraulic pump connected to the motor, and a piston unit comprising a piston housing and a piston arranged within the piston housing, a first liquid cavity and a second liquid cavity in communication with the bidirectional hydraulic pump being formed at both ends of the piston, respectively; and a mechanical transmission module, with both ends thereof connected to the piston and a downhole drilling tool, respectively, wherein the electronic control module is configured to transmit the ground control command to the hydraulic driving module, so that the motor drives the bidirectional hydraulic pump to generate high-pressure oil and low-pressure oil in the first liquid cavity and the second liquid cavity alternately, thus driving the piston to perform axial movement reciprocally under differential pressure, and the mechanical transmission module is configured to convert the axial movement of the piston into a rotational movement, in order to drive the downhole drilling tool to rotate and thus adjust downhole tool face.

[0009] In one embodiment, the electronic control module includes a circuit pressure-bearing cylinder, and a control circuit arranged inside the circuit pressure-bearing cylinder and in signal connection therewith.

[0010] In one embodiment, the directional tool further comprises an upper joint, a pressure-bearing shell and a mechanical transmission shell connected in sequence, wherein the electronic control module and the hydraulic driving module are arranged within the pressure-bearing shell, and the mechanical transmission module is arranged inside the mechanical transmission shell, an annular flow passage for circulation of drilling fluid being formed between the electronic control module, the hydraulic driving module and the pressure-bearing shell.

[0011] In one embodiment, the control circuit is installed inside the circuit pressure-bearing cylinder through a circuit framework, and configured to receive the ground control command through a cable connector.

[0012] In one embodiment, the hydraulic driving module further includes a motor housing fixedly connected to an upper end of the piston housing, and the motor and the bidirectional hydraulic pump are arranged within the motor housing.

[0013] In one embodiment, the hydraulic driving module further includes an oil bladder unit arranged between the electronic control module and the motor, for storing compensating hydraulic oil for balancing a difference between an internal pressure and an external pressure of the hydraulic driving module.

[0014] In one embodiment, the oil bladder unit is arranged between the circuit pressure-bearing cylinder and the motor housing, and comprises an oil bladder framework and a bladder arranged thereon, wherein an annular space for storing the compensating hydraulic oil is formed between the oil bladder framework and the bladder.

[0015] In one embodiment, a wire connector is installed inside the oil bladder framework, for connecting the control circuit to the motor.

[0016] In one embodiment, the upper joint and the circuit pressure-bearing cylinder are respectively provided with a first flow hole and a second flow hole extending through side walls thereof, the second flow hole corresponding to the oil bladder unit in position, wherein the drilling fluid from an uphole drilling tool flows to the oil bladder unit through the first flow hole, the annular flow passage and the second flow hole in sequence, in order to balance the difference between the internal and external pressures of the hydraulic driving module.

[0017] In one embodiment, the bidirectional hydraulic pump comprises a first oil port and a second oil port in communication with the first liquid cavity and the second liquid cavity respectively, and the hydraulic driving module further comprises a two-way hydraulic valve connected between the bidirectional hydraulic pump and the piston housing, wherein a first oil path and a second oil path respectively in communication with the first oil port and the second oil port are arranged within the two-way hydraulic valve.

[0018] In one embodiment, a first flow passage and a second flow passage in communication with the first liquid cavity and the second liquid cavity respectively are provided within a side wall of the piston housing, wherein the first flow passage is in communication with the first oil path to form a first hydraulic passage, and the second flow passage is in communication with the second oil path to form a second hydraulic passage, wherein the bidirectional hydraulic pump is configured to:

> when the motor rotates in a forward direction, suck the low-pressure oil from the second hydraulic passage, which is compressed to form the high-pressure oil and then transported to the first liquid cavity through the first hydraulic passage, so that the piston extends axially downward, and
> when the motor rotates in a reverse direction, suck the low-pressure oil from the first hydraulic passage, which is compressed to form the high-pressure oil and then transported to the second liquid cavity through the second hydraulic passage, so that the piston retracts axially upward.

[0019] In one embodiment, a first safety valve and a second safety valve are respectively provided in the first oil path and the second oil path of the two-way hydraulic valve.

[0020] In one embodiment, a pressure balance hole is arranged in the side wall of the piston housing, for communicating the annular flow passage with an upper area of the piston, in order to balance the pressure on both ends of the piston.

[0021] In one embodiment, a hydraulic joint is fixed to a lower end of the piston housing, wherein a lower end of the piston extends through the hydraulic joint to form a dynamic seal.

[0022] In one embodiment, an upper centralizer is arranged on an outer side of the circuit pressure-bearing cylinder, and a lower centralizer is arranged on an outer side of the hydraulic joint, for centralizing the electronic control module and the hydraulic driving module.

[0023] In one embodiment, the mechanical transmission module comprises a transmission shaft connected to the piston and a rotating cylinder adaptively connected to the transmission shaft, and is configured to drive the rotating cylinder to rotate through an axial movement of the transmission shaft.

[0024] In one embodiment, the transmission shaft is fixedly connected to the piston through a drive shaft, which has a central flow passage, and a third flow hole passing through a side wall thereof for communicating the central flow passage with the annular flow passage.

[0025] In one embodiment, a plurality of first key ways and a plurality of second key ways both evenly distributed along a circumferential direction are formed on an outer surface of the transmission shaft, wherein the first key ways and the second key ways are spaced apart along an axial direction and offset from each other at a certain angle circumferentially, so as to be in communication with but offset from each other along the circumferential direction, and at least one engaging protrusion is arranged on an inner surface of the rotating cylinder, and configured to alternately engage with one of the first key ways and one of the second key ways when the transmission shaft moves along the axial direction, thus driving the rotating cylinder to rotate.

[0026] In one embodiment, a first side wall at a lower end of each first key way is formed as a first guiding inclined surface, which is opposite to a corresponding second key way to receive the engaging protrusion from said second key way,

> a first side wall at an upper end of each second key way is formed as a second guiding inclined surface, which is opposite to a corresponding first key way to receive the engaging protrusion from said first key way, and
> a first engaging inclined surface that engages with the first guiding inclined surface is formed on a second side opposite to a first side, and at an upper end of the engaging protrusion, while a second engaging inclined surface that engages with the second guiding inclined surface is formed on the second side and at a lower end of the engaging protrusion.

[0027] In one embodiment, the mechanical transmission module further comprises:

> a ratchet cylinder, with an upper end thereof sleeved on the drive shaft, and a lower end thereof extending downward to engage with an upper end of the rotating cylinder, ratchets formed at the lower end of the ratchet cylinder and the upper end of the rotating cylinder being configured to engage with each other; and
> a spring, wherein a step with an end surface facing downward is provided on an inner wall of the mechanical transmission shell, and the spring is arranged between the step and an upper end surface of the ratchet cylinder, the lower end of the ratchet cylinder pressing tightly against the upper end of the rotating cylinder, in order to allow the rotating cylinder to rotate in only one direction.

[0028] In one embodiment, an output joint is fixedly connected to a lower end of the rotating cylinder for connecting to the downhole drilling tool, a sealing joint being arranged between the output joint and the mechanical transmission shell, and
the sealing joint is fixed connected to the mechanical transmission shell, and engages with both the rotating cylinder and the output joint through a thrust bearing, wherein a rotary sealing ring is arranged between the output joint and the sealing joint, in order to ensure a rotary seal therebetween.

[0029] Compared with the prior arts, the present application has the following advantages.

[0030] The mechanics-electronics-hydraulics integrated directional tool for coiled tubing drilling according to the present invention comprises a hydraulic driving module, which can realize bidirectional circulation of two flow passages through a bidirectional hydraulic pump and the piston's reciprocating movement through only one set of hydraulic assembly. Compared with the traditional two-set hydraulic assemblies, the structure according to the present invention is greatly simplified, while the reliability of the system is also significantly enhanced. Meanwhile, the mechanical transmission module can be locked reliably after the operation, thus avoiding slipping that may influence the rotation effect, and obviating the need for an additional self-locking structure. Besides, since there are only two upper and lower dead centers for the axial movement, there is no need for accurate positioning, which is convenient to control. The mechanics-electronics-hydraulics integrated directional tool for coiled tubing drilling is characterized by high reliability, which is able to facilitate on-site construction.

Brief Description of the Drawings

[0031] In the following, the present invention will be described with reference to the accompanying drawings.

> Fig. 1 shows a structure of a mechanics-electronics-hydraulics integrated directional tool for coiled tubing drilling according to the present invention.
>
> Fig. 2 schematically shows a retracted state of a piston in a hydraulic driving module.
>
> Fig. 3 schematically shows an extended state of the piston in the hydraulic driving module.
>
> Fig. 4 schematically shows a structure of a transmission shaft in a mechanical transmission module.
>
> Fig. 5 schematically shows a structure of a rotating cylinder in the mechanical transmission module.
>
> Fig. 6 schematically shows operating principles of the mechanical transmission module.

[0032] In the present application, all accompanying drawings are schematic ones, provided to illustrate the principle of the present invention merely, and are not necessarily drawn to actual scale.

Detailed Description of Embodiments

[0033] The present invention will be described below with reference to the accompanying drawings. It should be noted that the description as follows is provided to illustrate the principle of the present invention merely, and is not intended to restrict the scope of protection of the present invention.

[0034] For the sake of convenience, in the present application, an end proximate to the wellhead is defined as an upper end, an upstream end, or the like, such as an upper end in Fig. 1, while an end away from the wellhead is defined as a lower end, a downstream end, or the like, such as a lower end in Fig. 1.

[0035] Fig. 1 shows a structure of a mechanics-electronics-hydraulics integrated directional tool 100 for coiled tubing drilling according to the present invention. As shown in Fig. 1, the mechanics-electronics-hydraulics integrated directional tool 100 for coiled tubing drilling comprises an electronic control module 200, a hydraulic driving module 300, and a mechanical transmission module 400. The electronic control module 200 is configured to receive and execute ground control commands. The hydraulic driving module 300, which is arranged at a lower end of the electronic control module 200, includes a motor 14 in signal communication with the electronic control module 200, a bidirectional hydraulic pump 18 connected to the motor 14 and comprising a first oil port 19 and a second oil port 21, a piston housing 28, and a piston 27 adapted to the piston housing 28. The first oil port 19 and the second oil port 21 are respectively in communication with a first liquid cavity 201 and a second liquid cavity 202 (see Fig. 2) formed at upper and lower ends of the piston 27. The mechanical transmission module 400 arranged at a lower end of the hydraulic driving module 300 comprises a transmission shaft 41 connected to the piston 27, and a rotating cylinder 42 adaptively connected to the transmission shaft 41. The electronic control module 200 is able to transmit the ground control command to the hydraulic driving module 300 and control the motor 14 to rotate forward and backward, so that the bidirectional hydraulic pump 18 generates high-pressure oil and low-pressure oil at the first oil port 19 and the second oil port 21 respectively, and in communication with the first liquid cavity 201 and the second liquid cavity 202 alternately. In this manner, the piston 27 will, under a differential pressure between the high-pressure oil and the low-pressure oil, drive the transmission shaft 41 to move axially in a reciprocating manner. The mechanical transmission module 400 is configured to drive the rotating cylinder 42 to rotate through an axial movement of the transmission shaft 41, thus converting the axial movement of the transmission shaft 41 into a rotational movement of the rotating cylinder 42. Therefore, the downhole drilling tool connected to a lower end of the rotating cylinder 42 is driven to rotate, so as to adjust the downhole tool face.

[0036] As shown in Fig. 1, the mechanics-electronics-hydraulics integrated directional tool 100 for coiled tubing drilling further comprises an upper joint 1, a pressure-bearing shell 4 and a mechanical transmission shell 36, which are connected in sequence from top to bottom. The electronic control module 200 and the hydraulic driving module 300 are arranged within the pressure-bearing shell 4, and an annular flow passage 5 for circulation of the drilling fluid is formed between the electronic control module 200, the hydraulic driving module 300 and the pressure-bearing shell 4. The mechanical transmission module 400 is arranged inside the mechanical transmission shell 36.

[0037] In one embodiment, an upper end of the upper joint 1 is configured as a universal drill pipe buckle for connecting to an uphole drilling tool (not shown). A lower end of the upper joint 1 is configured as a positively tapered buckle which is fixedly connected to the pressure-bearing shell 4 through threads. Both ends of the pressure-bearing shell 4 are configured as negatively tapered buckles. An upper negatively tapered buckle of the pressure-bearing shell 4 is adapted to and fixedly connected to the positively tapered buckle of the upper joint 1 through threads, and a lower negatively tapered buckle thereof is adapted to and fixedly connected to the positively tapered buckle at an upper end of the mechanical transmission shell 36 through threads. Thus the pressure-bearing shell 4 serves as a protective shell for the electronic control module 200 and the hydraulic driving module 300 to withstand external impact on the directional tool and the differential pressure between the internal and external drilling fluid.

[0038] The upper joint 1 is provided with at least one first flow hole 3 extending through a side wall thereof. Preferably, two first flow holes 3 are symmetrically provided close to a lower end portion of the upper joint 1. The first flow holes 3 communicate an interior of the upper joint 1 with the annular flow passage 5, whereby the drilling fluid from the upper drilling tool can flow into the annular flow passage 5 through the first flow holes 3.

[0039] According to the present invention, as shown in Fig. 1, the electronic control module 200 includes a circuit pressure-bearing cylinder 6, and a control circuit 9 arranged inside the circuit pressure-bearing cylinder 6. The control circuit 9 is connected to a cable from the ground through a cable connector 2 and configured to receive and execute ground control commands. The control circuit 9 is installed inside the circuit pressure-bearing cylinder 6 through a circuit framework 8, so that the circuit pressure-bearing cylinder 6 is able to effectively protect the control circuit 9. A stepped mounting portion is provided at an upper end of the circuit pressure-bearing cylinder 6. The cable connector 2 is fixedly mounted on the stepped mounting portion, for connecting a cable inside the uphole drilling tool connected to an upper portion of the mechanics-electronics-hydraulics integrated directional tool 100 for coiled tubing drilling with the control circuit 9 inside the circuit pressure-bearing cylinder 6. The circuit framework 8 is arranged inside the circuit pressure-bearing cylinder 6, for mounting and supporting the control circuit 9.

[0040] In one embodiment, an upper centralizer 7 is installed close to the upper end of the circuit pressure-bearing cylinder 6 to ensure that the electronic control module 200 is centered properly.

[0041] According to the present invention, the hydraulic driving module 300 further includes a motor housing 16 fixedly connected to an upper end of the piston housing

28. The motor 14 and the bidirectional hydraulic pump 18 are both arranged within the motor housing 16. In one embodiment, an upper end of the motor housing 16 is fixedly connected to a lower end of the circuit pressure-bearing cylinder 6 through a positively tapered connection buckle, and a lower end of the motor housing 16 is fixedly connected to the upper end of the piston housing 28 through a positively tapered connection buckle. Annular gaps in communication with each other are formed between the circuit pressure-bearing cylinder 6, the motor housing 16, the piston housing 28 and the pressure-bearing shell 4, each annular gap forming a part of the annular flow passage 5.

[0042] As shown in Fig. 1, an oil bladder unit 10 is installed between the circuit pressure-bearing cylinder 6 and the motor housing 16. The oil bladder unit 10 comprises an oil bladder framework 11 and a bladder 15 arranged on the oil bladder framework 11. Compensating hydraulic oil is stored within the oil bladder unit 10, for balancing the difference between the internal and external pressures of the hydraulic driving module 300. Preferably, the compensating hydraulic oil is stored in an annular space formed between the oil bladder framework 11 and the bladder 15. The bladder 15 is made of flexible materials, such as rubber. The entire hydraulic driving module 300 is submerged in hydraulic oil. The oil is injected through an oil injection hole 17 of the motor housing 16, and part of the hydraulic oil is stored in the annular space between the oil bladder framework 11 and the bladder 15 as the compensating hydraulic oil. The circuit pressure-bearing cylinder 6 is provided with a second flow hole 13 extending through a side wall thereof. The second flow hole 13 corresponds to the oil bladder unit 10, so that the drilling fluid from the uphole drilling tool can flow to the oil bladder unit 10 through the first flow holes 3, the annular flow passage 5 and the second flow hole 13 in sequence. In this manner, the drilling fluid can act on the bladder 15 of the oil bladder unit 10 to balance the difference between the internal and external pressures of the hydraulic driving module 300. With regard to the internal and external pressures in the present application, it should be noted that the internal pressure refers to a pressure generated within the hydraulic driving module 300, while the external pressure refers to a pressure of the drilling fluid in the annular flow passage.

[0043] An upper end of the oil bladder framework 11 is inserted into the lower end of the circuit pressure-bearing cylinder 6, and a lower end of the oil bladder framework 11 is inserted into the upper end of the motor housing 16, thus forming fixed installation. A wire connector 12 is installed inside the oil bladder framework 11, for connecting control wires of the control circuit 9 with those of the motor 14 to facilitate the transmission of control signals.

[0044] According to the present invention, the hydraulic driving module 300 includes the oil bladder unit 10, the motor 14, and the bidirectional hydraulic pump 18 which are arranged in sequence from top to bottom and in fluid communication with each other. The oil bladder unit 10 comprises the oil bladder framework 11 and the bladder 15 made of, for example, rubber and arranged on the oil bladder framework 11. Compensating hydraulic oil is stored in the annular space formed between the oil bladder framework 11 and the bladder 15, and in communication with the hydraulic oil used by the bidirectional hydraulic pump 18.

[0045] It is readily comprehensible that although the hydraulic driving module 300 is provided with seals, the leakage of hydraulic oil in the motor 14 and the bidirectional hydraulic pump 18 is inevitable after prolonged use in the high-temperature and high-pressure downhole environment. According to the present invention, the oil bladder unit 10 is able to automatically provide hydraulic oil to the bidirectional hydraulic pump 18 when leakage occurs, in order to compensate for the loss of hydraulic oil and ensure the normal operation of the motor 14 and the bidirectional hydraulic pump 18. At the same time, it is unnecessary to replace the motor 14 or the bidirectional hydraulic pump 18.

[0046] After the compensating hydraulic oil of the oil bladder unit 10 is supplied to the bidirectional hydraulic pump 18, the hydraulic pressure acting on the bladder 15 made of rubber will deform the bladder 15, so as to eliminate vacuum possibly formed within the oil bladder unit 10, thus ensuring the normal operation of the hydraulic driving module 300.

[0047] Further, as mentioned above, the drilling fluid can flow to the oil bladder unit 10 through the first flow holes 3, the annular flow passage 5 and the second flow hole 13 in sequence, and exert on the bladder 15 of the oil bladder unit 10 made of flexible materials, thereby balancing the difference between the internal and external pressures of the hydraulic driving module 300. Therefore, the pressure-bearing capacity of each component in the hydraulic driving module 300 is improved, and the service life thereof can be extended.

[0048] The hydraulic driving module 300 further comprises a two-way hydraulic valve 20 connected between the bidirectional hydraulic pump 18 and the piston housing 28. The two-way hydraulic valve 20 is provided therein with a first oil path and a second oil path that are respectively in communication with the second oil port 21 and the first oil port 19 of the bidirectional hydraulic pump 18. A first flow passage 24 and a second flow passage 26, which are in communication with the first liquid cavity 201 and the second liquid cavity 202 respectively, are provided within a sidewall of the piston housing 28. The first flow passage 24 is in communication with the first oil path to form a first hydraulic passage, and both ends of the first hydraulic passage are respectively in communication with the first oil port 19 of the bidirectional hydraulic pump 18 and the first liquid cavity 201. The second flow passage 26 is in communication with the second oil path to form a second hydraulic passage, and both ends of the second hydraulic passage are respectively in communication with the second oil port 21 of the bidirectional hydraulic pump 18 and the second liquid cavity 202.

[0049] As shown in Fig. 1, the piston housing 28 is approximately cylindrical in shape. Two independent cavities, an upper cavity and a lower cavity, are formed within the piston housing 28. The upper cavity is for installing the two-way hydraulic valve 20, and the lower cavity is for adaptively installing the piston 27. Meanwhile, a hydraulic joint 29 is inserted and fixedly installed in a lower end of the piston housing 28. A sliding seal ring 30 is arranged between the hydraulic joint 29 and a lower end of a lower piston rod (see below) of the piston 27, so that a dynamic seal connection is formed therebetween. The lower end of the lower piston rod of the piston 27 extends outward through the hydraulic joint 29, so as to form a dynamic seal therebetween. The piston 27 is able to move within the cavity along an axial direction.

[0050] The piston 27 comprises a piston body, and an upper piston rod and a lower piston rod which are oppositely arranged at two axial ends of the piston body. The upper piston rod and the lower piston rod have equal diameters which are smaller than that of the piston body. The upper cavity and the lower cavity in the piston housing 28 are in communication with each other, a diameter of the upper cavity being smaller than that of the lower cavity. The upper piston rod is adaptively installed in the upper cavity and forms a seal with an inner wall of the upper cavity. The piston body is adaptively installed in the lower cavity and forms a seal with an inner wall of the lower cavity. An area of the lower cavity above an upper end surface of the piston body is formed as a first liquid cavity 201, while an area of the lower cavity below a lower end surface of the piston body is formed as a second liquid cavity 202. The first liquid cavity 201 is in communication with the first hydraulic passage, and the second liquid cavity 202 is in communication with the second hydraulic passage. During operation, the hydraulic driving module 300 enables the first liquid cavity 201 and the second liquid cavity 202 to be alternately in communication with high-pressure oil and low-pressure oil, so that a differential pressure can be formed between the upper and lower end surfaces of the piston body. Thus, the reciprocating movement of the piston 27 along the axial direction can be realized.

[0051] During operation, the hydraulic driving module 300 receives the ground control command transmitted by the electronic control module 200, so as to control the motor 14 to rotate in forward and reverse directions. When the motor 14 rotates in the forward direction, the first oil port 19 of the bidirectional hydraulic pump 18 sucks oil, so that the low-pressure oil within the second hydraulic passage is drawn back into the bidirectional hydraulic pump 18, where it is compressed to form high-pressure oil. Subsequently, the high-pressure oil is transported to the first liquid cavity 201 through the first hydraulic passage. At this time, the oil in the first liquid cavity 201 is high-pressure oil, while that in the second liquid cavity 202 is low-pressure oil, so that the piston 27 moves axially downward under the differential pressure between the high-pressure and low-pressure oil and extends outward. Fig. 3 shows an extended state of the piston 27 in the hydraulic driving module 300.

[0052] When the motor 14 rotates in the reverse direction, the second oil port 21 of the bidirectional hydraulic pump 18 sucks oil, so that the low-pressure oil in the first hydraulic passage is drawn back into the bidirectional hydraulic pump 18, where it is compressed to form high-pressure oil. Subsequently, the high-pressure oil is transported to the second liquid cavity 202 through the second hydraulic passage. At this time, the oil in the first liquid cavity 201 is low-pressure oil, while that in the second liquid cavity 202 is high-pressure oil, so that the piston 27 moves axially upward under the differential pressure between the high-pressure and the low-pressure oil and retracts. Fig. 2 shows a retracted state of the piston 27 in the hydraulic driving module 300.

[0053] According to an embodiment of the present invention, a first safety valve 22 and a second safety valve 23 are respectively provided in the first oil path and the second oil path of the two-way hydraulic valve 20. When the oil pressure in the two-way hydraulic valve 20 is abnormal (such as when the movement of the piston 27 is blocked or the circulating oil path is clogged), say, exceeding a set threshold of the first safety valve 22 or the second safety valve 23, the first safety valve 22 or the second safety valve 23 will be turned on automatically to discharge part of the oil to the low-pressure cavity, in order to ensure the safety of the entire hydraulic circulation system.

[0054] According to the present invention, the hydraulic driving module 300 includes only one bidirectional hydraulic pump 18, through which the bidirectional circulation of the two flow passages is realized, ensuring the reciprocating movement of the piston along the axial direction reliably. Compared with the traditional two sets of hydraulic assemblies, the structure of the tool according to the present invention has been significantly simplified, and the reliability of the system has been greatly enhanced.

[0055] **In** addition, with such an arrangement of the hydraulic driving module 300, the length of the entire directional tool 100 is significantly shortened. Generally speaking, the directional tool according to the present invention can be manufactured with a length of only 3.6 to 4 meters, which is reduced by approximately 15-30% compared to the directional tools in the prior arts. For example, in a particular embodiment, an overall length of the directional tool 100 according to the present invention is only about 3.8 meters. Compared with an overall length of about 5.5 meters in the prior arts, the length of the directional tool according to the present invention is reduced by about 30%. It is readily understood that such improvement is of great significance for the performance of the tool when passing through the wellbore curvature.

[0056] In one embodiment, a side wall of the piston housing 28 corresponding to the upper cavity is provided with a pressure balance hole 25, which is preferably arranged near a top portion of the upper cavity. The pressure balance hole 25 is configured to communicate the annular flow passage 5 with an upper area corresponding to the piston 27 inside the cavity, so that the drilling fluid pressure exerts on the piston rod above the piston 27. Therefore, the pressure of the drilling fluid exerted on the piston rod below the piston 27 can be balanced, while the vacuuming phenomenon generated during the movement of the piston 27 can be prevented.

[0057] Further, a lower centralizer 31 is provided on an outer side of the hydraulic joint 29 and configured to centralize the hydraulic driving module 300, in order to ensure the coaxiality of the connection between the piston 27 and the mechanical transmission module 400, reduce the off-axis resistance during the movement of the entire system, and enhance the efficiency of output thrust of the hydraulic driving module 300. During the operation, the upper centralizer 7 installed on the circuit pressure-bearing cylinder 6 works in cooperation with the lower centralizer 31 to effectively ensure the centralization of the electronic control module 200 and the hydraulic driving module 300.

[0058] According to the present invention, as shown in Fig. 1, the transmission shaft 41 is fixedly connected to a lower end of the piston 27 through a drive shaft 34 which has a central flow passage 35. Hence, when the piston 27 is driven by the hydraulic driving module 300 to move along the axial direction, the transmission shaft 41 can be driven by the piston 27 to move along the axial direction as well. The drive shaft 34 is provided with a third flow hole 33 extending through a side wall thereof, which is preferably arranged near an upper end thereof and configured to communicate the central flow passage 35 with the annular flow passage 5. Thus, the drilling fluid in the annular flow passage 5 between the electronic control module 200, the hydraulic driving module 300 and the pressure-bearing shell 4 can enter the central flow passage 35 of the drive shaft 34 of the mechanical transmission module 400 through the third flow hole 33, in order to realize the downward flow of the drilling fluid.

[0059] A limit cylinder 32 is arranged on the drive shaft 34 close to the upper end thereof. An upper end surface of the limit cylinder 32 is in contact with a lower end surface of the hydraulic joint 29 of the hydraulic driving module 300, while a lower end surface of the limit cylinder 32 is in contact with an upper end surface of the mechanical transmission shell 36, for limiting the hydraulic driving module 300 and preventing the hydraulic driving module 300 from moving downward when the piston 27 extends outward.

[0060] According to the present invention, as shown in Fig. 4, a plurality of first key ways 50 and a plurality of second key ways 60 both evenly distributed along the circumferential direction are formed on an outer surface of the transmission shaft 41. The first key ways 50 and the second key ways 60 are spaced apart along the axial direction, and offset from each other at a certain angle circumferentially. Thus the first key ways 50 and the second key ways 60 are in communication with but offset from each other along the circumferential direction. The first key ways 50 and the second key ways 60 all extend along the axial direction, and may be, for example, external spline key ways extending axially. As shown in Fig. 5, at least one engaging protrusion 70 is further arranged on an inner surface of the rotating cylinder 42. Preferably, a plurality of engaging protrusions 70 may be provided. More preferably, the first key ways 50, the second key ways 60 and the engaging protrusions 70 are equal in number. The engaging protrusions 70 are arranged at intervals along the circumferential direction, and may be, for example, internal key teeth extending axially. Since the first key ways and the second key ways are offset at a certain angle, the engaging protrusions 70 can alternately engage with the first key ways 50 and the second key ways 60 and move therebetween when the transmission shaft 41 moves axially, thus driving the rotating cylinder 42 to rotate.

[0061] As shown in Fig. 4, a first side wall at a lower end of each first key way 50 is formed as a first guiding inclined surface 51, which is opposite to the second key way 60 to receive the engaging protrusion 70 from the second key way 60. Moreover, a first side wall at an upper end of each second key way 60 is formed as a second guiding inclined surface 61, which is opposite to the first key way 50 to receive the engaging protrusion 70 from the first key way 50. In the meantime, as shown in Fig. 5, a first engaging inclined surface 71 that can engage with the first guiding inclined surface 51 is formed on a second side opposite to a first side, and at an upper end of the engaging protrusion 70, while a second engaging inclined surface 72 that can engage with the second guiding inclined surface 61 is formed on the second side and at a lower end of the engaging protrusion 70.

[0062] Therefore, when the engaging protrusion 70 moves upward relatively and leaves one of the second key ways 60, the first engaging inclined surface 71 at the upper end of the engaging protrusion 70 will engage with the first guiding inclined surface 51 at the lower end of a corresponding first key way 50. With the cooperation between the first guiding inclined surface 51 and the first engaging inclined surface 71, the engaging protrusion 70 can continue to move upward but with a circumferential offset, and thus enter the corresponding first key way 50 which is circumferentially offset from said second key way 60 at a certain angle. The cooperation between the first guiding inclined surface 51 and the first engaging inclined surface 71 is conducive to the stable movement of the engaging protrusion 70 relative to the first key way 50, and also realizes the rotation of the rotating cylinder 42.

[0063] When the engaging protrusion 70 moves downward relatively and leaves one of the first key ways 50, the second engaging inclined surface 72 at the lower end of the engaging protrusion 70 will engage with the second guiding inclined surface 61 at the upper end of a corresponding second key way 60. With the cooperation between the second guiding inclined surface 61 and the second engaging inclined surface 72, the engaging protrusion 70 can continue to move downward but with a circumferential offset, and thus enter the corresponding second key way 60 which is circumferentially offset from the first key way 50 at a certain angle. The cooperation between the second guiding inclined surface 61 and the second engaging inclined surface 72 is conducive to the stable movement of the engaging protrusion 70 relative to the second key way 60, and also realizes the rotation of the rotating cylinder 42.

[0064] In one preferred embodiment, the engaging protrusion 70 always engages with at least one of the first key way 50 and the second key way 60. That is to say, the engaging protrusion 70 will not disengage from the first key way 50 and the second key way 60 simultaneously.

[0065] Therefore, after the mechanics-electronics-hydraulics integrated directional tool 100 for coiled tubing drilling is assembled, the rotating cylinder 42 is located outside the transmission shaft 41, so that the engaging protrusion 70 on the rotating cylinder 42 can move between the first key way 50 and the second key way 60. When the engaging protrusion 70 is within the first key way 50 or the second key way 60, it engages with the first key way 50 or the second key way 60 in the circumferential direction through snap fitting, so that the transmission shaft 41 is fixed relative to the rotating cylinder 42 in the circumferential direction. During the drilling, the above arrangement can effectively avoid slipping phenomenon, as well as deviation of the drilling direction of the bottom hole assembly connected to the rotating cylinder 42.

[0066] In addition, as shown in Fig. 4, a neck portion 411 is also formed on the outer surface of the transmission shaft 41, and within a space between the first key ways 50 and the second key ways 60. Thus, when moving to the neck portion 411, the engaging protrusion 70 will not directly contact the outer surface of the transmission shaft 41, which reduces the frictional resistance between the rotating cylinder 42 and the transmission shaft 41 and thus enables the relative movement therebetween to be more flexible.

[0067] According to the present invention, the mechanical transmission module 400 also includes a ratchet cylinder 40. An upper end of the ratchet cylinder 40 is sleeved on the drive shaft 34, and a lower end thereof extends downward to an area outside of the transmission shaft 41 and engages with an upper end of the rotating cylinder 42. Ratchets are formed at an edge of the lower end of the ratchet cylinder 40, the function of which will be described in detail hereinafter.

[0068] As shown in Fig. 1, a step with an end surface facing downward is provided on an inner wall of the mechanical transmission shell 36, and a spring 38 is arranged between the step and an upper end surface of the ratchet cylinder 40. Preferably, an upper end of the spring 38 is pressed against the step via a balance block 37. After the mechanics-electronics-hydraulics integrated directional tool 100 for coiled tubing drilling is assembled, the spring 38 remains in a compressed state to tightly press the ratchet cylinder 40 downward, so that the lower end of the ratchet cylinder 40 is pressed tightly against the upper end of the rotating cylinder 42. It can be understood that the spring 38 can also be replaced by any other suitable elastic element.

[0069] Meanwhile, ratchets 421 are also formed at an edge of the upper end of the rotating cylinder 42 (see Fig. 5), and abut against to engage with the ratchets at the edge of the lower end of the ratchet cylinder 40 when pressed by the spring 38. When the rotating cylinder 42 rotates and the ratchets are in offset cooperation, the ratchet cylinder 40 compresses the spring 38, thus providing a space for axial movement. At the same time, the reverse rotation of the rotating cylinder 42 can be avoided through the cooperation between the ratchets. Additionally, spline grooves are machined on an outer surface of an upper portion of the ratchet cylinder 40. The ratchet cylinder 40 cooperates with splines provided on an inner wall of the mechanical transmission shell 36 through the spline grooves, in order to prevent rotation.

[0070] As shown in Fig. 1, an upper oil filling port 39 passing through the mechanical transmission shell 36 along a radial direction is further provided on a side wall of the mechanical transmission shell 36, for filling lubricating oil between the transmission shaft 41 and the mechanical transmission shell 36. The lubricating oil can flow in spaces between the transmission shaft 41 and the mechanical transmission shell 36, between the rotating cylinder 42 and the mechanical transmission shell 36, and a space where the transmission shaft 41 engages with the rotating cylinder 42. A detachable sealing plug is installed at the upper oil filling port 39. Thus, the relative movement between the rotating cylinder 42 and the transmission shaft 41 can be more flexible.

[0071] As shown in Fig. 1, an output joint 47 is fixedly connected to a lower end of the rotating cylinder 42 and configured to connect to the downhole drilling tool (not shown). In one embodiment, an upper end of the output joint 47 can be inserted into and connect to the lower end of the rotating cylinder 42 through threads. Thus, the rotation of the rotating cylinder 42 can drive the output joint 47 to rotate together. In this manner, the rotation of the rotating cylinder 42 can be transmitted to the downhole drilling tool, thus changing the drilling direction thereof. An axial space is provided between the upper end of the output joint 47 and a lower end of the transmission shaft 41 to allow the relative axial movement of the transmission shaft 41. Preferably, a sealing ring is arranged between the upper end of the output joint 47 and the lower end of the rotating cylinder 42, for preventing the wellbore fluid from flowing to the outside of the transmission shaft 41 through a connection between the output joint 47 and the rotating cylinder 42 and contaminating the lubricating oil.

[0072] Again, as shown in Fig. 1, a sealing joint 44 is arranged between the mechanical transmission shell 36 and the output joint 47. An upper end of the sealing joint 44 is inserted into a lower end of the mechanical transmission shell 36 to form a fixed connection through threads. The sealing joint 44 is arranged outside of the output joint 47, and a rotary sealing ring 46 is arranged on an inner side of the sealing joint 44. The rotary sealing ring 46 is engaged between the sealing joint 44 and the output joint 47, in order to ensure a sealed engagement therebetween when the output joint 47 rotates relative to the sealing joint 44.

[0073] An upper end surface of the sealing joint 44 is exactly opposite to a lower end surface of the rotating cylinder 42, with a thrust bearing 43 arranged therebetween. Meanwhile, an inner step with an end surface facing downward is provided on an inner wall of the sealing joint 44, and an outer step with an end surface facing upward is provided on an outer wall of the output joint 47. The inner step and the outer step are opposite to each other, with a thrust bearing 43 also arranged therebetween. Said two thrust bearings 43 are both arranged around the output joint 47 but axially spaced apart. The thrust bearings 43 are configured to transmit an axial pulling force of the mechanical transmission shell 36 while guiding the rotation of the rotating cylinder 42.

[0074] In one embodiment, the sealing joint 44 is also provided with a lower oil filling port 45 passing through a side wall thereof along the radial direction, for filling lubricating oil between the output joint 47 and the sealing joint 44, in order to lubricate the two thrust bearings 43. A detachable sealing plug is installed at the lower oil filling port 45.

[0075] The operating procedure of the mechanical transmission module 400 will be described in detail below with reference to Fig. 6.

[0076] Fig. 6 shows three working states of the mechanical transmission module 400, namely State I, State II and State III, which show the procedure during which the rotating cylinder 42 rotates at a preset directional angle.

[0077] In State I, the engaging protrusion 70 is located in a second key way 60A, in which case two side walls of the second key way 60A can effectively clamp the engaging protrusion 70. Therefore, the rotating cylinder 42 will not rotate relative to the transmission shaft 41, which can effectively ensure the orientation of the downhole drilling tool connected therebelow. Meanwhile, the spring 38 presses the ratchet cylinder 40 downward, enabling the ratchets at the lower end thereof to mesh with the ratchets at the upper end of the rotating cylinder 42.

[0078] The piston 27 is driven to extend by the hydraulic driving module 300 to press the transmission shaft 41 downward, so that the transmission shaft 41 moves downward relative to the rotating cylinder 42. Thus, the engaging protrusion 70 is able to move upward relative to the second key way 60A to proceed to State II.

[0079] In State II, the engaging protrusion 70 is about to disengage from the second key way 60A, in which case the first engaging inclined surface 71 at the upper end of the engaging protrusion 70 engages with the first guiding inclined surface 51 at a lower end of the first key way 50C and sandwiched between the first key ways 50B and 50C.

[0080] During the procedure from State I to State II, the rotating cylinder 42 has not yet rotated. Therefore, in State II the ratchets of the ratchet cylinder 40 and the rotating cylinder 42 remain meshed together. Thus, the rotating cylinder 42 will not rotate in the reverse direction even if the engaging protrusion 70 has been released from the limitation of a side wall surface of the second key way 60A.

[0081] As the hydraulic driving module 300 further presses the piston 27 and then the transmission shaft 41 downwards, and with the cooperation between the first engaging inclined surface 71 of the engaging protrusion 70 and the first guiding inclined surface 51 of the first key way 50C, the engaging protrusion 70 will turn to move towards the first key way 50C (away from the first key way 50B) and thus enter into the first key way 50C. During this procedure, the rotating cylinder 42 rotates at a preset angle not only relative to the transmission shaft 41 but also relative to the ratchet cylinder 40. The ratchets at the upper end of the rotating cylinder 42 are offset from the ratchets at the lower end of the ratchet cylinder 40, which mesh together again after rotating said preset angle to proceed to State III.

[0082] In State III, the engaging protrusion 70 is in the first key way 50C, limited by left and right sidewall surfaces thereof. Thus, the rotating cylinder 42 will not rotate relative to the transmission shaft 41 again, which effectively ensures the orientation of the downhole drilling tool connected therebelow.

[0083] Similarly, the rotating cylinder 42 can rotate again in the same direction at a preset angle when the hydraulic driving module 300 drives the piston 27 to retract to lift up the transmission shaft 41, so that the engaging protrusion 70 moves to another second key way 60D adjacent to the second key way 60A (on a left side thereof). Thus every time the transmission shaft 41 moves, the rotating cylinder 42 is driven to rotate at an angle, in order to adjust the downhole tool face.

[0084] The hydraulic driving module 300 drives the piston 27 to extend and retract alternately, thereby driving the continuous reciprocating motion of the transmission shaft 41 along the axial direction. Thus, the orientation of the rotating cylinder 42 can be changed continuously, which is highly efficient and beneficial in case of large drilling angle change of the downhole drilling tool.

[0085] The overall structure of the mechanics-electronics-hydraulics integrated directional tool 100 for coiled tubing drilling according to the present invention in a working state is shown in Fig. 1. The electronic control module 200 receives the ground control command through the cable, and controls the forward and reverse rotations of the motor 14 in the hydraulic driving module 300, thus driving two different oil outlets of the bidirectional hydraulic pump 18 to discharge oil. Thus the bidirectional hydraulic pump 18 alternately forms high-pressure oil and low-pressure oil in the first hydraulic passage and the second hydraulic passage respectively, so that the first liquid cavity 201 and the second liquid cavity 202 are alternately in communication with the high-pressure oil and the low-pressure oil, thereby forming a differential pressure between the upper and lower end surfaces of the piston 27 and realizing the reciprocating movement of the piston 27 along the axial direction. The piston 27 drives the transmission shaft 41 of the mechanical transmission module 400 connected to the drive shaft 34 to move in a straight reciprocating manner. Through the mechanical cooperation between the transmission shaft 41 and the rotating cylinder 42, the straight reciprocating movement of the transmission shaft 41 is converted into the rotational movement of the rotating cylinder 42, so that the rotating cylinder 42 drives the output joint 47 to rotate, and further drives the downhole drilling tool connected to the lower end of the output joint 47 to rotate, thus adjusting the downhole tool face. In this manner, the directional operation for coiled tubing drilling can be achieved.

[0086] The mechanics-electronics-hydraulics integrated directional tool 100 for coiled tubing drilling according to the present invention comprises a hydraulic driving module 300, which can realize bidirectional circulation of two flow passages through a bidirectional hydraulic pump 18. Compared with the traditional two-set hydraulic assemblies, the structure according to the present invention is greatly simplified, while the reliability of the system is also significantly enhanced. Meanwhile, the mechanical transmission module 400 can be locked reliably after the operation, thus avoiding slipping that may influence the rotation effect, and obviating the need for an additional self-locking structure. Besides, since there are only two upper and lower dead centers for the axial movement, there is no need for accurate positioning, which is convenient to control. The mechanics-electronics-hydraulics integrated directional tool 100 for coiled tubing drilling is characterized by high reliability, which is able to significantly improve the directional efficiency.

[0087] Finally, it should be noted that the foregoing description is merely illustrative of preferred embodiments of the present invention, and is not intended to restrict the present invention. Although the present invention is described in detail with reference to the above embodiments, it is still possible for one skilled in the art to modify the technical solutions defined in the above embodiments or to replace some of the technical features with equivalent ones. Any modifications, equivalent substitutions, improvements, and the like falling within the spirit and principles of the present invention are intended to be included within the scope of protection of the present invention.

Claims

1. A directional tool for coiled tubing drilling, comprising:

   an electronic control module (200), for receiving a ground control command;
   a hydraulic driving module (300), which comprises a motor (14) in signal connection with the electronic control module (200), a bidirectional hydraulic pump (18) connected to the motor (14), and a piston unit comprising a piston housing (28) and a piston (27) arranged within the piston housing, a first liquid cavity (201) and a second liquid cavity (202) in communication with the bidirectional hydraulic pump (18) being formed at both ends of the piston, respectively; and
   a mechanical transmission module (400),with both ends thereof connected to the piston and a downhole drilling tool, respectively,
   wherein the electronic control module is configured to transmit the ground control command to the hydraulic driving module, so that the motor drives the bidirectional hydraulic pump to generate high-pressure oil and low-pressure oil in the first liquid cavity and the second liquid cavity alternately, thus driving the piston to perform axial movement reciprocally under differential pressure, and
   the mechanical transmission module is configured to convert the axial movement of the piston into a rotational movement, in order to drive the downhole drilling tool to rotate and thus adjust downhole tool face.

2. The directional tool for coiled tubing drilling according to claim 1, **characterized in that** the electronic control module (200) includes a circuit pressure-bearing cylinder (6), and a control circuit (9) arranged inside the circuit pressure-bearing cylinder and in signal connection therewith.

3. The directional tool for coiled tubing drilling according to claim 2, **characterized in that** the directional tool further comprises an upper joint (1), a pressure-bearing shell (4) and a mechanical transmission shell (36) connected in sequence,
   wherein the electronic control module (200) and the hydraulic driving module (300) are arranged within the pressure-bearing shell (4), and the mechanical transmission module (400) is arranged inside the mechanical transmission shell (36), an annular flow passage (5) for circulation of drilling fluid being formed between the electronic control module (200), the hydraulic driving module (300) and the pressure-bearing shell (4).

4. The directional tool for coiled tubing drilling according to claim 2 or claim 3, **characterized in that** the control circuit is installed inside the circuit pressure-bearing cylinder through a circuit framework (8), and configured to receive the ground control command through a cable connector (2).

5. The directional tool for coiled tubing drilling according to claim 4, **characterized in that** the hydraulic driving module (300) further includes a motor housing (16) fixedly connected to an upper end of the piston housing, and the motor (14) and the bidirectional hydraulic pump (18) are arranged within the motor housing.

6. The directional tool for coiled tubing drilling according to claim 5, **characterized in that** the hydraulic driving module (300) further includes an oil bladder unit (10) arranged between the electronic control module (200) and the motor (14), for storing compensating hydraulic oil for balancing a difference between an internal pressure and an external pressure of the hydraulic driving module.

7. The directional tool for coiled tubing drilling according to claim 6, **characterized in that** the oil bladder unit (10) is arranged between the circuit pressure-bearing cylinder (6) and the motor housing (16), and comprises an oil bladder framework (11) and a bladder (15) arranged thereon, wherein an annular space for storing the compensating hydraulic oil is formed between the oil bladder framework (11) and the bladder (15).

8. The directional tool for coiled tubing drilling according to claim 7, **characterized in that** a wire connector (12) is installed inside the oil bladder framework, for connecting the control circuit to the motor.

9. The directional tool for coiled tubing drilling according to claim 7 or claim 8, **characterized in that** the upper joint (1) and the circuit pressure-bearing cylinder (6) are respectively provided with a first flow hole (3) and a second flow hole (13) extending through side walls thereof, the second flow hole (13) corresponding to the oil bladder unit (10) in position,
wherein the drilling fluid from an uphole drilling tool flows to the oil bladder unit through the first flow hole, the annular flow passage and the second flow hole in sequence, in order to balance the difference between the internal and external pressures of the hydraulic driving module.

10. The directional tool for coiled tubing drilling according to claim 1, **characterized in that** the bidirectional hydraulic pump (18) comprises a first oil port (19) and a second oil port (21) in communication with the first liquid cavity (201) and the second liquid cavity (202) respectively, and the hydraulic driving module further comprises a two-way hydraulic valve (20) connected between the bidirectional hydraulic pump (18) and the piston housing (28), wherein a first oil path and a second oil path respectively in communication with the first oil port (19) and the second oil port (21) are arranged within the two-way hydraulic valve (20).

11. The directional tool for coiled tubing drilling according to claim 10, **characterized in that** a first flow passage (24) and a second flow passage (26) in communication with the first liquid cavity and the second liquid cavity respectively are provided within a side wall of the piston housing, wherein the first flow passage is in communication with the first oil path to form a first hydraulic passage, and the second flow passage is in communication with the second oil path to form a second hydraulic passage,
wherein the bidirectional hydraulic pump is configured to:

    when the motor rotates in a forward direction, suck the low-pressure oil from the second hydraulic passage, which is compressed to form the high-pressure oil and then transported to the first liquid cavity through the first hydraulic passage, so that the piston extends axially downward, and
    when the motor rotates in a reverse direction, suck the low-pressure oil from the first hydraulic passage, which is compressed to form the high-pressure oil and then transported to the second liquid cavity through the second hydraulic passage, so that the piston retracts axially upward.

12. The directional tool for coiled tubing drilling according to claim 10 or claim 11, **characterized in that** a first safety valve (22) and a second safety valve (23) are respectively provided in the first oil path and the second oil path of the two-way hydraulic valve.

13. The directional tool for coiled tubing drilling according to any one of claims 1 to 12, **characterized in that** a pressure balance hole (25) is arranged in the side wall of the piston housing, for communicating the annular flow passage with an upper area of the piston, in order to balance the pressure on both ends of the piston.

14. The directional tool for coiled tubing drilling according to any one of claims 1 to 3, **characterized in that** a hydraulic joint (29) is fixed to a lower end of the piston housing, wherein a lower end of the piston extends through the hydraulic joint to form a dynamic seal.

15. The directional tool for coiled tubing drilling accord-

ing to claim 14, **characterized in that** an upper centralizer (7) is arranged on an outer side of the circuit pressure-bearing cylinder, and a lower centralizer (31) is arranged on an outer side of the hydraulic joint, for centralizing the electronic control module and the hydraulic driving module.

16. The directional tool for coiled tubing drilling according to claim 1, **characterized in that** the mechanical transmission module (400) comprises a transmission shaft (41) connected to the piston and a rotating cylinder (42) adaptively connected to the transmission shaft, and is configured to drive the rotating cylinder to rotate through an axial movement of the transmission shaft.

17. The directional tool for coiled tubing drilling according to claim 16, **characterized in that** the transmission shaft is fixedly connected to the piston through a drive shaft (34), which has a central flow passage (35), and a third flow hole (33) passing through a side wall thereof for communicating the central flow passage (35) with the annular flow passage (5).

18. The directional tool for coiled tubing drilling according to claim 16 or 17, **characterized in that** a plurality of first key ways (50) and a plurality of second key ways (60) both evenly distributed along a circumferential direction are formed on an outer surface of the transmission shaft, wherein the first key ways and the second key ways are spaced apart along an axial direction and offset from each other at a certain angle circumferentially, so as to be in communication with but offset from each other along the circumferential direction, and
at least one engaging protrusion (70) is arranged on an inner surface of the rotating cylinder, and configured to alternately engage with one of the first key ways and one of the second key ways when the transmission shaft (41) moves along the axial direction, thus driving the rotating cylinder to rotate.

19. The directional tool for coiled tubing drilling according to claim 18, **characterized in that** a first side wall at a lower end of each first key way is formed as a first guiding inclined surface (51), which is opposite to a corresponding second key way to receive the engaging protrusion from said second key way,

a first side wall at an upper end of each second key way is formed as a second guiding inclined surface (61), which is opposite to a corresponding first key way to receive the engaging protrusion from said first key way, and
a first engaging inclined surface (71) that engages with the first guiding inclined surface is formed on a second side opposite to a first side, and at an upper end of the engaging protrusion, while a second engaging inclined surface (72) that engages with the second guiding inclined surface is formed on the second side and at a lower end of the engaging protrusion.

20. The directional tool for coiled tubing drilling according to claim 16, **characterized in that** the mechanical transmission module further comprises:

a ratchet cylinder (40), with an upper end thereof sleeved on the drive shaft (34), and a lower end thereof extending downward to engage with an upper end of the rotating cylinder, ratchets formed at the lower end of the ratchet cylinder and the upper end of the rotating cylinder being configured to engage with each other; and
a spring (38), wherein a step with an end surface facing downward is provided on an inner wall of the mechanical transmission shell, and the spring is arranged between the step and an upper end surface of the ratchet cylinder, the lower end of the ratchet cylinder pressing tightly against the upper end of the rotating cylinder, in order to allow the rotating cylinder to rotate in only one direction.

21. The directional tool for coiled tubing drilling according to claim 16, **characterized in that** an output joint (47) is fixedly connected to a lower end of the rotating cylinder (42) for connecting to the downhole drilling tool, a sealing joint (44) being arranged between the output joint and the mechanical transmission shell, and
the sealing joint is fixed connected to the mechanical transmission shell, and engages with both the rotating cylinder and the output joint through a thrust bearing (43), wherein a rotary sealing ring (46) is arranged between the output joint and the sealing joint, in order to ensure a rotary seal therebetween.

22. The directional tool for coiled tubing drilling according to any one of claims 1 to 21, **characterized in that** a length of the directional tool for coiled tubing drilling ranges from 3.6 to 4 meters.

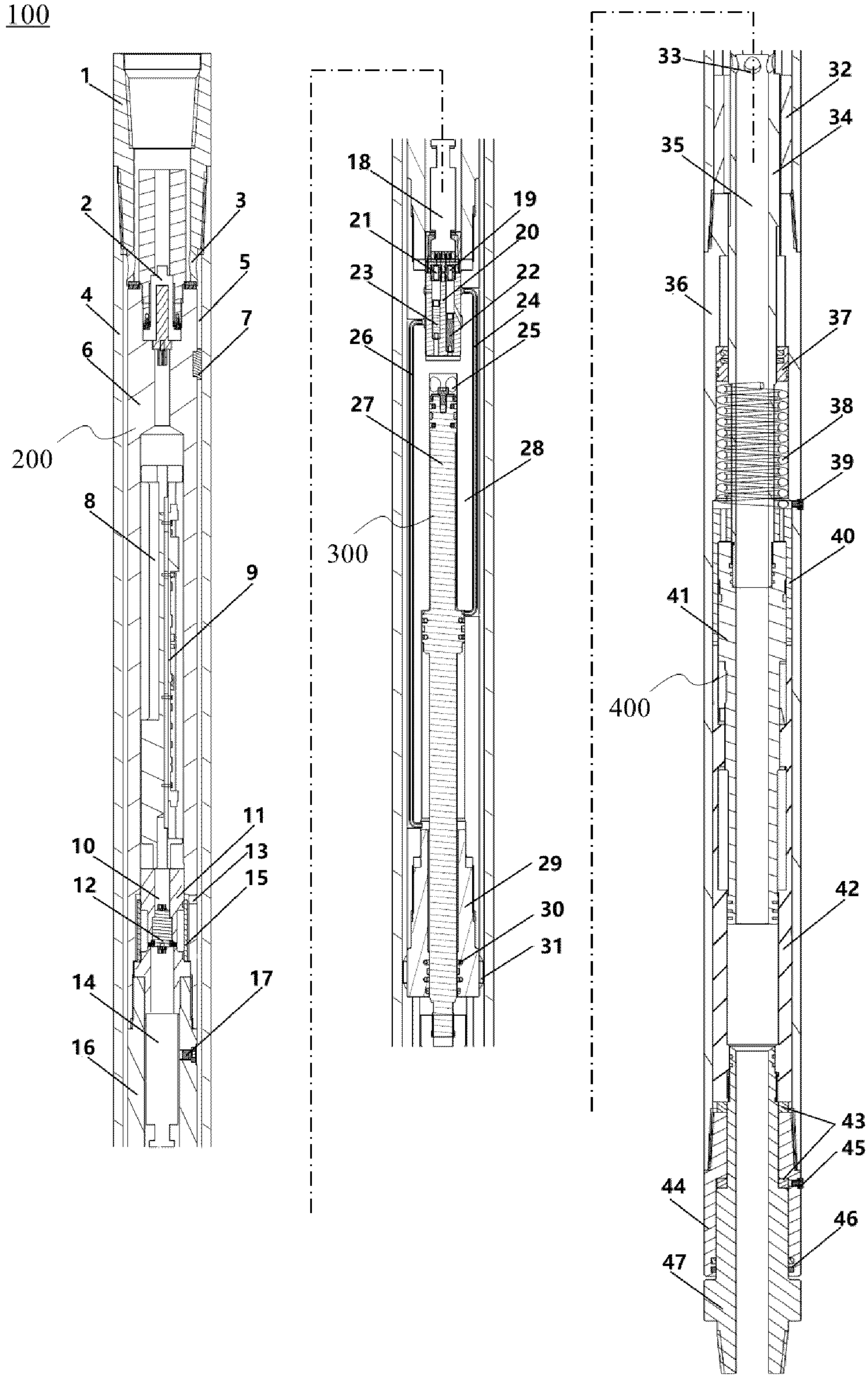
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Fig. 1

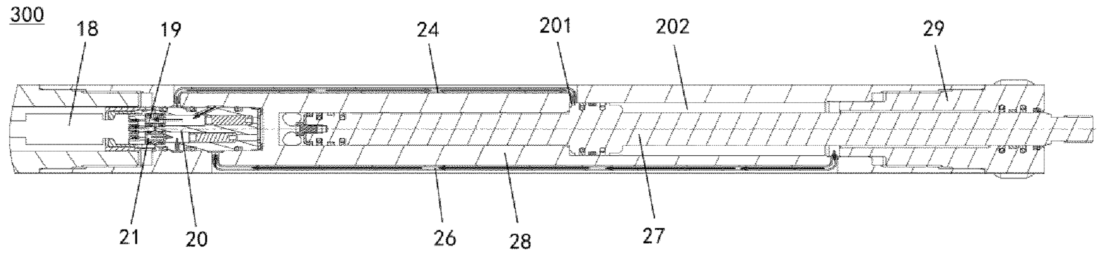


Fig. 2

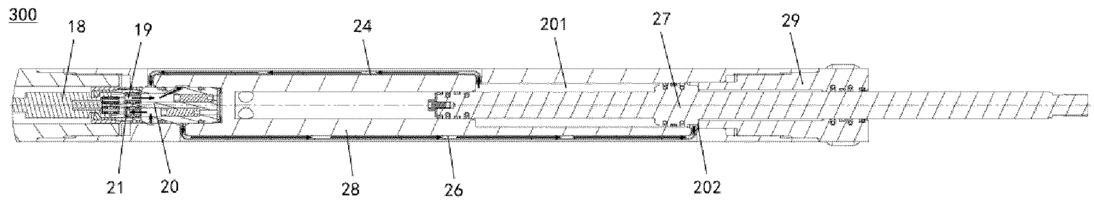


Fig. 3

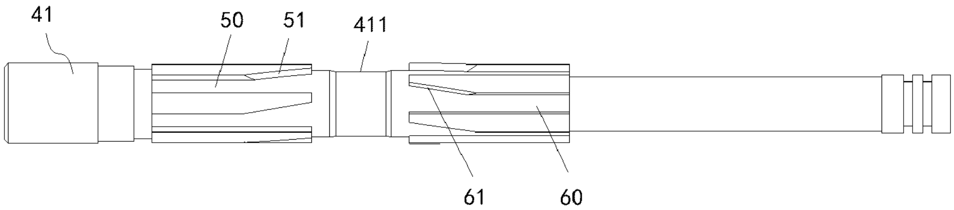


Fig. 4

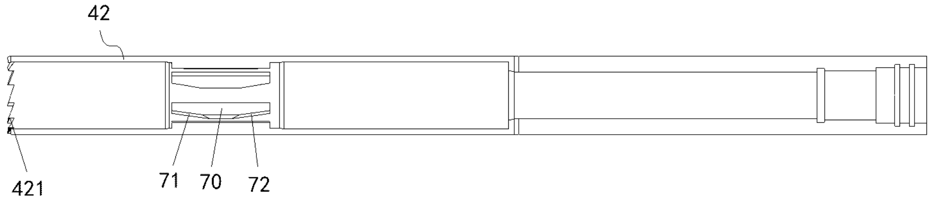
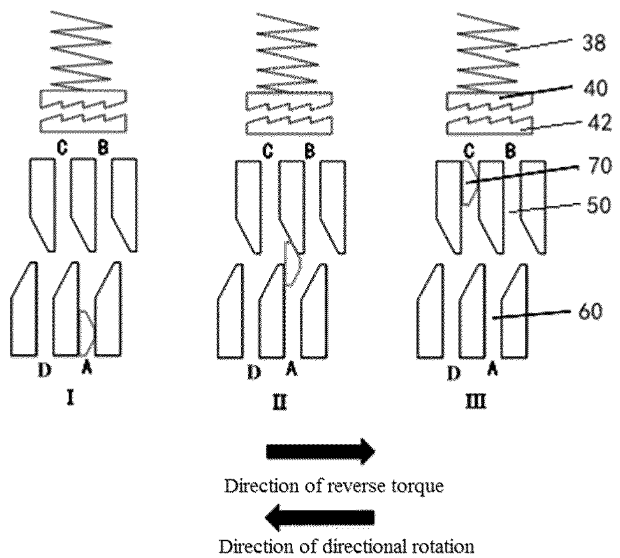


Fig. 5


38
40
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C
B
70
50
60
D
A
I
II
III
Direction of reverse torque
Direction of directional rotation

Fig. 6

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2023/103937

A. CLASSIFICATION OF SUBJECT MATTER

E21B7/04(2006.01)i

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC：E21B7

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

CNTXT, ENTXTC, VEN, CNKI: 钻, 定向, 连续管, 连续油管, 电机, 电动机, 马达, 活塞, drill+, direction+, steer+, orient+, coiled, tubing, motor?, piston?, plunger?

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	CN 105888550 A (CHINA NATIONAL PETROLEUM CORP. et al.) 24 August 2016 (2016-08-24) description, paragraphs 48-86, and figures 1-4	1-22
Y	EP 1245783 A2 (ANADRILL INTERNATIONAL S. A. et al.) 02 October 2002 (2002-10-02) description, paragraphs 20-31, and figures 1-4	1-22
Y	CN 114508520 A (CHINA PETROLEUM & CHEMICAL CORP. et al.) 17 May 2022 (2022-05-17) description, paragraphs 25-36, and figures 1-3	6-9, 14-15
Y	CN 114109256 A (CHINA PETROLEUM & CHEMICAL CORP. et al.) 01 March 2022 (2022-03-01) description, paragraphs 23-52, and figures 1-4	16-21
A	CN 105134071 A (CHINA NATIONAL PETROLEUM CORP. et al.) 09 December 2015 (2015-12-09) entire document	1-22
A	CN 106050144 A (PEI XUJIAN) 26 October 2016 (2016-10-26) entire document	1-22

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

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“&” document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
22 September 2023	**27 September 2023**
Name and mailing address of the ISA/CN **China National Intellectual Property Administration (ISA/CN)** **China No. 6, Xitucheng Road, Jimenqiao, Haidian District, Beijing 100088**	Authorized officer Telephone No.

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2023/103937

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2012145462 A1 (LEISING, Larry J. et al.) 14 June 2012 (2012-06-14) entire document	1-22

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INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2023/103937

Patent document cited in search report	Publication date (day/month/year)	Patent family member(s)	Publication date (day/month/year)
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EP 1245783 A2	02 October 2002	EP 0787886 A2	06 August 1997
		CA 2196633 A1	08 August 1997
		US 6047784 A	11 April 2000
		DE 69717875 D1	30 January 2003
CN 114508520 A	17 May 2022	None	
CN 114109256 A	01 March 2022	None	
CN 105134071 A	09 December 2015	None	
CN 106050144 A	26 October 2016	None	
US 2012145462 A1	14 June 2012	US 8960330 B2	24 February 2015

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REFERENCES CITED IN THE DESCRIPTION

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