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(54) **HYDRAULIC CYLINDER, OIL PUMPING UNIT, OIL PUMPING MODULE AND OIL PUMPING SYSTEM**

(57) The present invention provides a hydraulic cylinder, an oil pumping unit, an oil pumping module and an oil pumping system. The hydraulic cylinder provided in the present invention comprises a hydraulic cylinder body, a piston, a first piston rod and a second piston rod; said second piston rod extending out of the hydraulic cylinder in a direction opposite to that of the first piston rod. Said oil pumping unit comprises said hydraulic cylinder and a first oil-well pump that engages the first piston rod. Said oil pumping module comprises such an oil pumping unit, a control mechanism and a hydraulic driving mechanism. Said oil pumping system is composed of one or a plurality of above recited oil pumping modules, each is connected with the final oil outlet through an oil pipeline that is connected with its own oil outlet opening. Compared with prior arts, the oil pumping system of the present invention comprises less components and its configuration is much simpler; it also **characterized** of simpler transmission mechanism and more efficient transmission mechanism, further, since the present invention employs groupware/module assembly, therefore, the installation is much simpler and highly flexible, and the reliability and safety of the system have been markedly improved.

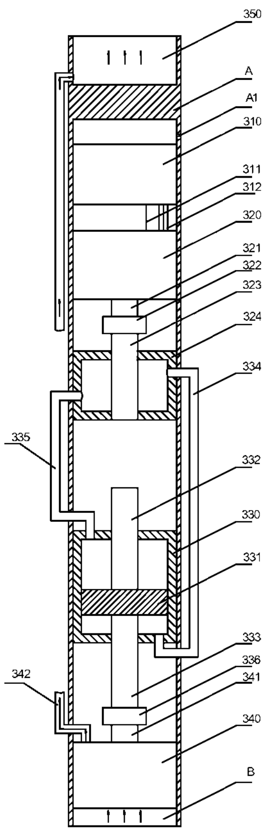

Fig.1

EP 2 280 174 A1

Description

Field of the Invention

[0001] The present invention relates to an oil extraction equipment used in oilfield, and more particularly, to an oil pumping system as well as an oil pumping module, an oil pumping unit and a hydraulic cylinder used in such an oil pumping equipment.

Background of the Invention

[0002] Generally, oil is recovered from oil reservoir in two methods, namely natural flow production and artificial lift oil production. Rod oil pumping system, the most important artificial lift oil production means adopted in oilfields both at home and aboard, is primarily composed of a pump jack, an oil sucker rod and an oil-well pump. The pump jack is the most essential device for artificial lift in a rod oil pumping system.

[0003] Pump jacks are divided into two categories in terms of the presence of a beam, namely, the beam oil pump jack and the non-beam pump jack. The beam pump jack, such as nodding donkey that is most widely applied in oilfield, recovers oil based on the reciprocating movement of the oil sucker rod pulled by a rocker-arm lever driven by a motor. Such a conventional structure has satisfied the industrial requirements to some extent, however, with the technical progress in mechanical and electric apparatus, such beam pump jack has shown many structural disadvantages, for example, the heavy hammer required for balancing the oil pumping results in big size and huge weight of the pump jack as well as the great consumption of steel material. Especially, with the increase in the stroke length, the size and weight of the pump jack increase sharply, the manufacturing process becomes longer and the installation procedures become more complicated. In addition, the vertical reciprocating travel distance of the pump jack is shorter than that of the existing oil-well pump, so that it is impossible to give full play to the efficiency of the existing oil-well pump. To match the travel distance of the oil-well pump, even bigger size and higher power of the pump jack is required. Other disadvantages of the conventional beam oil pump jack include the following: the conversion efficiency from rotary motion to linear reciprocating movement is low due to the losses of transmission efficiency of the belt, the gearbox reducer and the three shaft of the four bar mechanism. Gearbox of even bigger size and weight is required to increase the stroke distance due to the proportionally increased torque of the gearbox.

[0004] Various technical solutions have been provided to address the above mentioned problems. For example, Chinese Patent Application No. 89217947.3 provides a solution of using the oil pipe pillar as the balance mechanism. Chinese Patent Application No.200620166023.0 provides an improved installation approach. Chinese Patent Application No.92201875.8 relates to an improved hydraulic cylinder. Chinese Patent Application No.200620020553.4 relates to an improved structure of the hydraulic cylinder. Chinese Patent Application No.02155159.6 provides an improved mechanism for power transmission of the pump jack. Chinese Patent Application No. 200620119484.2, No.200420031970.X and No.200710052554.6 also relate to improvement of the pump jack.

[0005] Additionally, the excessive length of the oil sucker rod may easily lead to instantaneous expansion and/or compression of the beam. Such deformation of the oil sucker rod not only decreases the efficiency of the oil-well pump, but also causes frequent collision and friction between the oil sucker rod and the oil pipe. To solve such deficiency, some technical solutions are correspondingly provided, for example, Chinese Patent Application No.02237843.X provides an oil recovery device based on signal feedback, and Chinese Patent Application No.200610068939.7 discloses a hydraulic oil pumping device.

[0006] Chinese Patent Application No.99234396.8, and No.99250803.7 provide the examples of non-beam oil pump jack. Although non-beam oil pump jack has higher mechanical transmission efficiency than the beam oil pump jack, they are more complicated in structure and lower in reliability and thus have not been widely applied up to now.

[0007] Both beam and non-beam oil pump jacks suffer from friction wear that occurs on the position between the oil sucker rod and the oil pipe. Huge amount of energy is consumed for lifting the oil sucker rods as long as hundreds of meters or even more than thousand meters at each time of oil pumping.

[0008] In each of the present oil pumping systems, including those disclosed in the above-mentioned patents, to realize the reciprocating motion of the piston in the hydraulic cylinder, the power transmission mechanism is required to comprise an oil storage tank and an overflow valve and other accessories of these components, wherein the oil storage tank is used for liquid refilling of the hydraulic cylinder, and the overflow valve is used for limiting the maximum pressure of the liquid in the pipeline. These additional components have not only resulted in higher structural complexity and higher energy consumption of system, but also decrease the reliability and safety of the system.

[0009] Furthermore, many major oilfields have entered high water-cut development stage in succession. At this stage, in order to guarantee stable and sufficient oil output, it is necessary to increase the fluid lifting capacity of oil wells. As a result, the energy consumption of oil recovery system sharply increases and become one of the major factors boosting the production cost. However, at present no solution to this problem has been provided.

Summary of the Invention

[0010] In view of the deficiency of the prior art, the purpose of the present invention, namely the technical problem to be solved, is to provide a hydraulic cylinder, oil pumping unit, an oil pumping module and an oil pumping system which are characterized of simplified structure, higher efficiency and lower energy consumption.

[0011] To address said technical problem, the present invention provides a hydraulic cylinder comprising a hydraulic cylinder body, a piston, a first piston rod connected with said piston and a second piston rod connected with said piston; said second piston rod extends out of the hydraulic cylinder in the direction being opposite to that of said first piston rod. Said hydraulic cylinder is divided by said piston into an upper chamber and a lower chamber; at least one oil inlet/ outlet opening is set on said hydraulic cylinder body corresponding to said upper chamber and the lower chamber respectively.

[0012] The present invention also provides an oil pumping unit comprising said hydraulic cylinder and a first oil-well pump, said first piston rod of said hydraulic cylinder is connected with the oil sucker rod of said first oil-well pump , and an oil outlet is provided on said first oil-well pump.

[0013] As an improved solution, the above-mentioned oil pumping unit further comprises a second oil-well pump, the oil sucker rod of which is connected with said second piston rod of said hydraulic cylinder , and an oil outlet is also provided on said second oil-well pump.

[0014] The present invention further provides an oil pumping module comprising the above oil pumping unit and a control mechanism and a hydraulic driving mechanism, wherein said oil pumping unit is connected with said hydraulic driving mechanism through a hydraulic oil pipe, and said hydraulic driving mechanism is connected with said control mechanism, the control mechanism controls the operation of the hydraulic driving mechanism. Said hydraulic driving mechanism drives the piston in the hydraulic cylinder in said oil pumping unit to make vertical reciprocal motion, and thus drives the oil sucker rod of oil-well pump to make reciprocal oil pumping operation.

[0015] Said hydraulic driving mechanism in said oil pumping module comprises a two-way pump and an electric motor, which are connected with each other through a shaft coupling, and said two-way pump is connected with the first and the second hydraulic oil pipes of the hydraulic cylinder in said oil pumping unit. More specifically, said two-way pump is a gear pump and said electric motor is an AC servo motor.

[0016] Said control mechanism is a control circuit comprising a central processor, a servo control unit and an information acquisition unit; wherein said servo control unit comprises an encoder and a servo controller that corresponds and control the operation of the AC servo motor, said information acquisition unit generally comprises a variety of sensors, such as current sensor, position sensor, travel switch etc. Since this control mechanism is designed based on conventional technique, it is unnecessary to give more details of it herein.

[0017] The present invention also provides an oil pumping system comprising one or more said oil pumping modules. Each of said oil pumping modules is connected with the final oil outlet through the pipeline that is connected with its oil outlet. When a plurality of said oil pumping modules are used in the system, they are connected to each other through coupling means.

[0018] As compared with the prior art, the oil pumping system provided by the present invention is simpler in transmission and higher in transmission efficiency. Particularly, it obviates the oil sucker rod in excessive length of hundreds of meters or even more than one thousand meters, and eliminates the friction loss occurs between the oil sucker rod and the oil pipe. Therefore, as compared with the existing beam pumping system, this system reduces energy consumption exponentially.

[0019] The oil pumping system provided by the present invention has a higher reliability, because it is simple in structure and require less components, and furthermore, the entire system is operated underground, so it is free from environmental influence on the ground. In addition, the present invention fundamentally can eliminate security risks, specifically, the entire system is operated underground, therefore no *smash accidents* and personal injury, sometimes can be fatal, to workers occur on the ground, which cannot be avoided according to the existing beam pumping system upon attending of the operator.

[0020] The oil pumping system of the present invention is designed based on modules, therefore depending on the delivery capacity of each oil well, different quantity of modules may be assembled. Furthermore, the oil lifting capacity of each module can be controlled, so that the configuration and installation of the system is very flexible and convenient.

[0021] The oil pumping system provided by the present invention features flexible control strategy. Because this system adopts servo system, the control strategy can be adopts flexibly based on requirements of each oil well. for example, intermittent oil pumping mode may be used for production in oilfield of low output scale so as to save energy, however, the bigger security risks lie in the intermittent oil pumping mode in prior art, but there is no such security risks in the intermittent oil pumping mode applied in the present invention.

[0022] The following is a detailed description of the present invention with reference to the attached figures and examples of the embodiments.

Brief Description of the Drawings

[0023] Fig. 1 shows the schematic structure of the oil pumping system of embodiment 1;
[0024] Fig.2 shows the installation and configuration of the oil pumping system of embodiment 1;
[0025] Fig. 3 shows the schematic structure of the oil pumping system of embodiment 2;
[0026] Fig. 4 shows the schematic structure of the oil pumping module of the oil pumping system of embodiment 3;
[0027] Fig. 5 shows the schematic structure of the final oil outlet of the oil pumping system of embodiment 3;
[0028] Fig. 6 shows the overall structure of the oil pumping system of embodiment 3;
[0029] Fig.7 shows the position of the limit switch of the hydraulic cylinder of the oil pumping system;
[0030] Fig. 8 shows the schematic structure of the oil-well pump in the process of up stroke;
[0031] Fig. 9 shows the schematic structure of the oil-well pump in the process of down stroke;
[0032] Fig. 10 shows the schematic structure of the oil pumping system when the oil discharge pipes of both the oil-well pump and hydraulic cylinder are arranged inside the main pipe;
[0033] Fig. 11 shows the schematic structure of the oil pumping system when the entire pumping system is fitted inside the main pipe;
[0034] Fig.12 shows another schematic structure when the entire pumping system is fitted inside the main pipe;
[0035] Fig.13 shows how the entire pumping system is fixed inside the main pipe;
[0036] Fig.14 shows another manner of how the entire pumping system is fixed inside the main pipe;
[0037] Fig.15 depicts the speed variation of the oil-well pump;
[0038] Fig.16 depicts the variation of the force exerted on the main pipe according to embodiment 1;
[0039] Fig.17 depicts the variation of the force exerted on the main pipe according to embodiment 2;
[0040] Fig.18 depicts the variation of the force exerted on the main pipe according to embodiment 3;
[0041] Fig.19 is a schematic diagram of the installation of the oil pumping system of embodiment 4;
[0042] Fig.20 shows a schematic diagram of the appearance of the oil pumping module of embodiment 4;
[0043] Fig.21 shows a schematic diagram of the overall structure of the oil pumping module without the housing body according to embodiment 4;
[0044] Fig.22 is a partial cross-sectional diagram of the oil pumping module according to embodiment 4;
[0045] Fig.23 shows a schematic diagram of the overall structure of the oil pumping module without the outer housing according to embodiment 5;
[0046] Fig.24 is a partial cross-section diagram of the oil pumping module according to embodiment 5;
[0047] Fig.25 is a partial cross-sectional diagram of the oil pumping module according to embodiment 6;
[0048] Fig.26 shows a schematic diagram of the oil flow route inside the oil pumping module according to embodiment 7;
[0049] Fig.27 shows a schematic diagram of the oil flow route inside the oil pumping module according to embodiment 8;
[0050] Fig.28 shows the electrical cable connector of the present invention;
[0051] Fig.29 shows the connection between the motor and the two-way pump;
[0052] Fig.30 shows how the travel distance of the hydraulic cylinder is controlled with a magnetic sensing element;
[0053] Fig.31 shows how the travel distance of the hydraulic cylinder is controlled with a contact switch.

Embodiments

[0054] The hydraulic cylinder provided in the present invention comprises a hydraulic cylinder body, a piston, a first piston rod and a second piston rod, said two piston rods extend out of the hydraulic cylinder in the directions being opposite to each other. Said hydraulic cylinder body is divided into upper and lower chambers by said piston, and at least one oil inlet/outlet opening is set on said hydraulic cylinder body corresponding to the upper chamber and the lower chamber respectively t, and said oil inlet/outlet opening is communicated with the hydraulic driving mechanism through the first and second hydraulic oil pipes respectively.

[0055] The conventional oil storage tank that is necessary in prior art is obviated in the present invention, because the hydraulic cylinder of the present invention comprises two piston rods extending out of the cylinder body such that the total volume of the hydraulic chamber does not vary during the oil circulation and thus the total amount of the oil in circulation does not change. Additionally, oil pressure may be controlled by the control mechanism, and the overflow valve and other components for oil pressure balance may be obviated. Therefore, the oil pumping system of the present invention has much simpler overall structure and transmission mechanism. Moreover, each hydraulic sucker rod is connected with an oil-well pump so that oil pumping efficiency is significantly improved.

[0056] To summarize, a hydraulic cylinder and one or two oil-well pump compose one oil pumping unit. A pumping unit, a control mechanism plus a hydraulic driving mechanism compose one oil pumping module. One module or a plurality of such modules composes one oil pumping system. Therefore, such an oil pumping system is of simpler configuration, installation and easy maintenance, and it has high efficiency, low energy consumption and better safety.

Embodiment 1

[0057] Fig. 1 shows the schematic structure of the oil pumping system of embodiment 1. According to this embodiment, the oil pumping system is installed inside a main pipe A, the bottom portion of which is filled with oil B from the oil reservoir. The oil pumping system comprises an oil pumping module comprising a control mechanism, a hydraulic driving mechanism and an oil pumping unit. The oil pumping unit comprises a hydraulic cylinder and an oil-well pump. The control mechanism comprises a CPU, a servo motor controller, an encoder, relevant sensors (For example, a current sensor and a position sensor) and a corresponding peripheral circuit. The hydraulic driving mechanism comprises a two-way pump and an AC servo motor, wherein the AC servo motor corresponds to the servo motor controller of the control mechanism. The main pipe A abuts the bottom end of the main oil pipeline, and it holds the whole oil pumping system so that all components of the oil pumping system are provided with the main pipe, as shown in Fig. 1.

[0058] To facilitate an installation, the control mechanism including the CPU, the servo motor controller and the peripheral circuits etc is integrated in a controller box, i.e. servo controller box 310. The oil pumping system is powered through an electric cable which is introduced from above ground through cable inlet A1 of the main pipe. The motor encoder signal cable 311 of the AC servo motor 320 and the power supply cable 312 of the motor are both connected to the servo controller box 310. Power is supplied from above ground through a cable introduced through cable inlet A1 of the main pipe to the servo controller box 310, and the power supply end of the AC servo motor 320 is connected with the three-phase current output of the servo controller box. CPU detects the motor’s position and current value after every interval (60 microseconds for instance) according to the preset controlling strategy (For instance, the rotation rate of the motor is set constant). The encoder detects the position signal of the motor, the rotation angle of the motor is converted into an electrical signal, which is transmitted to the CPU in the servo controller box. The current sensor detects the value of the three-phase current, and based on such a value, CPU calculates and controls the appropriate voltage applied to the motor, and a closed-loop control of the motor is thus realized. The AC servo motor 320 is connected to the axis 323 of the two-way pump through a shaft coupling 321 to drive said two-way pump 324, and the two-way pump thereof is typically a gear pump. The two-way pump 324 is connected with the hydraulic cylinder 330 through the first hydraulic oil pipe 334 and the second hydraulic oil pipe 335. When the AC servo motor 320 driving the two-way pump 324 rotates in one direction, the oil under the hydraulic force flows in the corresponding direction so that the hydraulic piston 331 moves in the corresponding direction. When the AC servo motor 320 driving the two-way pump 324 rotates in the other direction, the oil under the hydraulic force flows in the other direction so that the hydraulic piston 331 moves in the other direction. Being connected with the hydraulic piston 331, the second piston rod 332 and the first piston rod 333 thus reciprocates along with the hydraulic piston 331. The first oil sucker rod 341, being connected with the first piston rod 333, also reciprocates together with the first piston rod so that the oil is recovered by the oil-well pump, and the recovered oil is carried to the main oil outlet 350 of the oil pumping system through the oil discharge pipe 342 of the oil-well pump 340.

[0059] Fig.2 shows the installation and configuration of the oil pumping system of embodiment 1; wherein the main oil outlet 350 joins the main oil pipeline 360 through connection means 361. Before the main oil pipeline extends out from under the ground D and is fixed by fixing means C on the ground, the main pipe A and the main oil pipeline 360 both are arranged inside the oil-well, and the inner side the oil-well wall is lined with a steel protective tubing E, and the outer side of the oil-well wall is a layer of cement F.

[0060] This embodiment further includes the following features: the second piston rod 332 and the first piston rod 333 extend out of the hydraulic cylinder. When the two-way pump 324 rotates in one direction, the hydraulic oil of the two-way pump 324 flows from the first hydraulic pipe 334 to the upper chamber of the cylinder , namely the upper space above the hydraulic piston 331, so as to propel the hydraulic piston 331 to move downward; at this moment, the hydraulic oil in the lower hydraulic chamber of the cylinder, namely the lower space under the hydraulic piston 331, flows to the two-way pump 324 through the second hydraulic pipe 335, thus a circulative flow of the hydraulic oil is formed. When the two-way pump 324 rotates in another direction, a reverse circulation of the hydraulic oil is formed. The above features show that the present invention obviates the oil refilling mechanism and the pipe pressure balancing mechanism, which are necessary components in prior art. That is, it requires fewer components and has simplified the objects to be controlled by the control mechanism. Further, the hydraulic cylinder and the AC servo motor of this embodiment have high efficiency and simple transmission mechanism, therefore the overall efficiency of the present invention is remarkably improved than prior art. The present invention also obviates the excessively lengthy oil sucker rod that is as long as hundreds of or even more than one thousand meters, and has succeeded in eliminating the friction loss between the oil sucker rod and the oil pipe and the energy loss occurred while lifting the oil sucker rod, therefore, compared with the prior art beam oil pumping systems, the present invention reduces energy consumption exponentially.

Embodiment 2

[0061] Fig. 3 shows the schematic structure of the oil pumping system of embodiment 2. What different from embodiment 1 is that two oil-well pumps, such as the oil-well pumps 340’ shown in fig. 3, are included in the oil pumping unit in this embodiment of the present invention. The two discharge pipes, 342, 342', of the two pumps are joined together and led to the main oil outlet 350.

[0062] As compared with the embodiment 1, this embodiment fully employs the hydraulic cylinder 324, and the first piston rod 332 is connected with the second oil-well pump 340', therefore, when the piston 331 of the hydraulic cylinder reciprocates, the first and second oil-well pump 340' work alternatively so that the oil recovery efficiency is doubled.

Embodiment 3

[0063] Figs. 4-6 show the schematic structure of the oil pumping system of embodiment 3. According to this embodiment, a plurality of oil pumping modules may be combined together to form an oil pumping system. In this specific embodiment, three modules are combined into an oil pumping system. The oil pumping module in this embodiment is illustrated in Fig. 4, and it is basically the same with that in embodiments 1 and 2, so the details will be omitted hereto. Fig. 5 shows the schematic structure of the final oil outlet of the oil pumping system of embodiment 3. The final oil outlet consists of the main oil outlet 350 and the oil inlets 351 and 352, there can be one, two or three oil inlets, there are two in Fig. 5. Fig. 6 shows the finished assembly where the final oil outlet is joined with each of the oil pumping module. It shows that the final oil outlet and the oil pumping module are joined with a connection means, and all the oil pumping modules are also connected with one another with the same connection means. Said connection means may be a threaded screw or a flange etc. The oil recovered by the oil-well pump of each oil pumping module is transported to the main oil outlet 350, which is connected with the main oil pipeline and carries the oil to ground. See Fig. 1 for the details.

[0064] Additionally, in order to control the travel distance of the hydraulic cylinder, two limit switches313 and 314 are provided respectively at the highest and lowest positions of the hydraulic cylinder, as illustrated in Fig. 7. The position limiting signal is transmitted to servo controller box 310, which instructs the AC servo motor 320 rotate clockwise or counter-clockwise corresponding to the limit signal so that the hydraulic cylinder 330 and the oil-well pump 340 may reciprocate. The limit switch may be replaced with other non-contact sensors, such as a hall sensor or an infrared (IR) limit sensor. Or it may be that no limit switch or sensors is used, and when the hydraulic piston reaches the highest or lowest position and the current of the servo motor increases sharply, such an sharply increased current signal may be used to control the rotation direction of the servo motor. Another alternative is that the rotation angle of the servo motor may be used to calculate the travel distance of the hydraulic piston, and based on such calculated travel distance when the rotation direction of the servo motor is changed.

[0065] Figs. 30 and 31 illustrate a specific example of how the travel distance of the hydraulic cylinder is controlled; wherein Fig. 30 shows how the travel distance of the hydraulic cylinder is controlled with a magnetic sensing element, taking the oil pumping module shown in Fig. 22 as an example. A magnetic steel is provided on the oil sucker rod 451, a magnetic sensing element 492 is provided at the bottom end of the flange that connects the hydraulic cylinder 440 and the oil-well pump 450. Said magnetic sensing element 492 is encased by the protective cover 498 and is connected to the servo controller 410 through signal cable 493. When the oil sucker rod 451 moves downward, the magnetic steel 491 also moves along downwards. When the magnetic steel 491 moves close to the magnetic sensing element 492, the latter produces an inductive signal and sends the inductive signal through signal cable 493 to the servo controller 410, which then instructs the servo mother 420 rotate reversely and the oil sucker rod is moved up. When the oil sucker rod 451 moves upward, the position of the servo motor 420 is monitored and controlled, that is, the rotation circles of the motor is monitored and when it reaches a predetermined number, the servo motor 420 is instructed to rotate forwardly, and the oil sucker rod 451 then moves downwards. Thus the reciprocating movement of the oil sucker rod 451 is realized.

[0066] Certainly, the magnetic sensing element492 may also be mounted at the top end of the flange, or it may be that a magnetic sensing element is installed at both the top and bottom end of the flange respectively for limiting the travel distance.

[0067] Fig.31 shows how the travel distance of the hydraulic cylinder is controlled with a contact switch, and the following Fig. 31 shows the schematic structure of such a contact switch. A magnetic steel 491' is provided at the lower end of the oil sucker rod 451, a protective cover 498' is provided at the bottom end of the flange, an elastic sheet 494 is fixed on the protective cover 498', another magnetic steel 492' having an opposite polarity than the magnetic steel 491' is provided on the elastic sheet 494, a contact point 495 is also provided on the protective cover 498', the free end of the contact point 495 faces the free end of the elastic sheet 494 at a certain distance between them. The elastic sheet 494 and the contact point 495 are connected to the servo controller 410 respectively through signal cable 495 and 496. When the oil sucker rod 451 moves downwards, the magnetic steel 491'on such oil sucker rod 451 also moves downward. When the two magnetic steels 491' and 492' having opposite polarities move close to each other, absorbing force is produced and the elastic sheet 494 is bended, and its free end contacts that of the contact point 495, thus there is conduction between the signal cables 495 and 496. When the two signal cables 495 and 496 are conductive to each other, the servo controller 410 instructs the servo motor 420 rotate reversely, and the oil sucker rod 451 moves upward. When the oil sucker rod 451 moves upward, the position of the servo motor 420 is monitored and controlled. That is, when the rotation circles of the motor reaches a predetermined number, the servo motor 420 is instructed to rotate forwardly, and the oil sucker rod 451 then moves downward. Thus the reciprocating movement of the oil sucker rod 451 is realized.

[0068] Certainly, the contact switch may also be mounted at the top end of the flange, or it may be that the contact switch is installed at both the top and bottom end of the flange respectively for limiting the travel distance.

[0069] The oil-well pump in the above embodiment may be just of conventional configuration. Figs. 8 and 9 show the schematic structure of a typical oil-well pump; wherein Fig. 8 depicts the up stroke and Fig. 9 depicts the down stroke. The oil sucker rod 341 is connected with the traveling valve cover 3441, and the traveling valve cover 3441 is fixed onto the traveling valve stand 3461, which is connected with piston 347. The traveling valve ball 3451 is located in the space between the traveling valve stand 3461 and the traveling valve cover 3441, and the fixed valve ball 3452 is located in the space between the fixed valve stand 3462 and the fixed valve cover 3442. Oil enters the oil-well pump from the fixed valve and flow out of the oil-well pump through oil discharge pipe 342. The oil discharge pipe of the oil-well pump carries oil to the main oil outlet, which leads to the main oil pipeline, and oil is carried to the ground through the main oil pipeline.

[0070] Additionally, the oil pumping system may be installed inside the main pipe in various manners. Figs. 10-14 illustrate other installation methods besides the one depicted in embodiment 1. Although these illustrations take the oil pumping system of Fig. 1 as an example, obviously, the installation methods depicted thereof are also applicable for other oil pumping systems recited in other embodiments.

[0071] Fig. 10 shows the schematic structure of the oil pumping system when the oil discharge pipes of both the oil-well pump and the hydraulic cylinder are arranged inside the main pipe. With all the components of the system installed within the main pipe, this is a highly compact structure, and all the components may get protection from the main pipe. However, such a structure requires more careful and ingenious arrangement, and mutual disturbance among the different components should be avoided.

[0072] As shown in Fig. 11, with no separate oil transmission pipe provided for carrying the oil to the main oil outlet, oil recovered by the oil-well pump enter the interior chamber of the main pipe directly, and the main pipe is communicated to the main oil pipeline. In such a case, all the components are soaked in the oil in the main oil pipeline and bear pressure from the oil, which imposes higher requirement of pressure durability on all the components. However, the advantage of such structure is that there has to be no concern about the airtight condition between the separate oil transmission pipe and the main pipeline, for there is no separate interim oil transmission pipe provided.

[0073] Fig. 12 is a special example of Fig. 11, wherein the oil-well pump and the main pipe is combined into one integral body, with the outer wall of the oil-well pump being used as the main pipe. Many of the conventional oil pumping systems have such design of the oil-well pump. The advantage of such simple structure is that it makes use of the conventional pumps and thus reduces production cost. The disadvantage is that it requires higher pressure durability of the components, and it does not well facilitate the connection between the multiple modules of embodiment 3.

[0074] Fig. 13 and Fig. 14 show two different ways of how the components of the oil pumping system are mounted onto the main pipe. Fig. 13 shows that each component is mounted onto the main pipe directly. Fig. 14 shows that each component is firstly fixed onto a long strip, and then the long strip is fixed onto the main pipe. The latter allows that all the components can be assembled onto the long strip, then all the components and the long strip can be set in the main pipe all together, and then only the long strip is fixed onto the main pipe, such finishes the installation which makes the installation of the oil pumping system more convenient.

Embodiment 4

[0075] Referring to Figs. 19-22, wherein Fig. 19 is a schematic diagram of the installation of the oil pumping system of embodiment 4, Fig.20 is a schematic diagram of appearance of the oil pumping module of embodiment 4, Fig.21 is a schematic diagram of the overall structure the oil pumping module without the outer housing according to embodiment 4, and Fig.22 is a partial cross-sectional diagram of the oil pumping module according to embodiment 4. Compared with the previous embodiments, this embodiment features a different method for fixing the equipments. Figs. 13-14 show the methods for fixing the equipments according to embodiments 1-3. In this embodiment, the oil pumping system is a module assembly 400 comprising a housing body 401, and it is fixed onto the main pipe 460 with flange 403; wherein the servo controller box 410, AC servo motor 420, two-way pump 430, hydraulic cylinder 440, oil-well pump 450 are sequentially connected with one another with flange. Oil circulation between the two-way pump 430 and the hydraulic cylinder 440 are facilitated by the hydraulic pipes 471 and 472, oil recovered by the oil-well pump 450 is transmitted to the main oil pipeline 460 from the flange 403 through the interim oil pipe 461 and 462.

[0076] Referring to Fig. 22, the two-way pump 430 is a gear pump, its two-way shaft 431 is connected with a gear 432, and the two-way shaft 431 is connected the output shaft of the AC servo motor 420 through a shaft coupling 481, and the two-way pump is connected to the hydraulic cylinder 440 with flange. There is a piston 442 inside of said hydraulic cylinder 440, and two piston rods 441 and 443 extend out of the two ends of the hydraulic cylinder 440 respectively. The piston rod 443 engages the oil sucker rod 451 of the oil-well pump through a shaft coupling 482. According to this embodiment, the housing body 401 is used for protecting and supporting all the components inside, and it has an oil inlet opening, which allows the oil enter the module chamber from exterior and supply oil to the oil-well pump.

Embodiment 5

[0077] Referring to Figs. 23-24, Fig.23 shows the overall structure the oil pumping module without the outer housing according to embodiment 5, and Fig.24 is a partial cross-section diagram of the oil pumping module according to embodiment 5. Embodiment 5 differs from embodiment 4 in that two oil-well pump 450 and 450'are configured to the hydraulic cylinder of the oil pumping system.

Embodiment 6

[0078] Referring to Fig. 25, which shows the partial cross-sectional diagram of the oil pumping module according to embodiment 6. The oil pumping system according to this embodiment may be composed of a plurality of oil pumping modules connected in series, as shown in the dotted line boxes. Each oil pumping module according to this embodiment may be of embodiment 4 or of embodiment 5, and the interim oil pipe of each module is connected with each other and is connected with the main oil pipeline. Such series configuration of a plurality of oil pumping modules is capable of increasing the fluid lifting capacity and the oil output largely.

Embodiment 7

[0079] Fig.26 shows the oil flow route inside the oil pumping module according to embodiment 7. According to this embodiment, the housing body 701 is provided with an oil inlet opening 702, the oil-well pump 750 is communicated to the oil outside of the housing body 701 through an oil inlet pipe connected with the oil inlet opening 702. An oil outlet opening 751 is provided at an appropriate position of the oil-well pump 750 for discharging the recovered oil into the internal chamber of the housing body, which is communicated with the main oil pipeline through a channel on flange 703. According to this embodiment, the internal chamber of the oil pumping module is perfectly airtight, and oil from outside of the main pipe is sucked into the oil-well pump through its inlet pipe, and the internal chamber of the oil pumping module is then used as an interim oil pipe and carries the oil to the main oil pipeline. The advantage of such a structure is that less interim oil pipes are needed, and concerns as to the airtight condition and installation of such interim pipes are also obviated. However, all the components are soaked in the oil and bear pressure from the oil, therefore, pressure durability and airtight condition of the individual component are of concerns.

Embodiment 8

[0080] Fig.27 shows the oil flow route inside the oil pumping module according to embodiment 8, which differs from the embodiment 7 in that the oil-well pump 850 is communicated to the oil outside of the housing body 801 through an oil inlet pipe connected with the oil inlet opening 802. At an appropriate position of the oil-well pump 850, an interim oil pipe 861 is connected with the main oil pipeline. In this embodiment, because the internal chamber of the oil pumping module is perfectly airtight, oil from outside is sucked into the oil-well pump through the oil inlet pipe, and the oil recovered by the oil-well pump is transmitted to the main oil pipeline through interim oil pipes. The advantage of this configuration is that the oil is transported completely in the pipes, and the internal chamber of the oil pumping module will carry no oil, therefore, pressure durability and airtight condition of each component, such as, the motor and the controller etc. are not of concern. Only the oil pipeline's pressure durability and airtight condition should be concerned.

[0081] In addition, the control mechanism is connected to the equipments on the ground through a cable, therefore the airtight condition at the joint of the cable and the servo motor controller is critical. In this embodiment, the cable connector as shown in Fig. 28 is employed. One end of such a connector is the cable end 91, the other end is the control wiring end 93. The cable and the cable end 91 are joined together, and their joint is sealed through glue potting. The wiring of the control mechanism is inserted into the wiring opening 94 of the control wiring end 93 and is fixed onto the control mechanism through flange 92. Such configuration and wiring result in better airtight condition of the equipment and facilitate on-site installation.

[0082] A protector is provided at the output terminal of the servo motor of each embodiment. Taking embodiment 1 as an example, Fig. 29 shows the connection between the motor 320 and the two-way pump 324. Said protector 380 is communicated with the interior of the motor 320 and is filled up with insulating oil. It is only through the protector that the oil from outside enters the interior of the motor through the end of the shaft of the motor so that such a protector functions as a protective means and balances the pressure between the interior and exterior of the motor by keeping them to be the same with each other. Such pressure balance between the interior and exterior of the motor is critical to maintain the airtight condition of the motor.

[0083] The reciprocating movement of the oil-well pump during the process of oil recovery involves acceleration and deceleration, which varies the force exerted on the main oil pipeline, i.e. it causes vibration of the main oil pipeline, the more intense this vibration, the more fatigue is caused to the main oil pipeline, and the deterioration of the main oil pipeline is intensified. The present invention has provided an ideal solution to this problem, it enables the force exerted on the main oil pipeline to be even and has effectively reduced the deterioration of the main oil pipeline. Below is detailed analysis of the force exerted on the main oil pipeline according to the above three embodiments.

[0084] The mass of the fluid in the main oil pipeline is:

$$m = \rho V = \rho S h$$

Wherein, m-----the mass of the fluid in the oil pipeline
ρ ----- the density of the fluid in the oil pipeline
S -----the cross-sectional area of the oil pipeline
h----height of the oil in the oil pipeline
Assuming: $\rho = 1\times10^3 kg/m^3$ $S = 60 \times 10^{-4} m^2$, $h = 2000m$
Then: $m = 1 \times 10^3 \times 60 \times 10^{-4} \times 2000 = 12000kg$

[0085] When the oil-well pump reciprocates vertically, at the beginning period of both the up stroke and down stroke, the oil sucker rod is in acceleration. Therefore, assuming: the acceleration $a=1m/s^2$

[0086] For the above three embodiments, the speed variation of the oil sucker rod is illustrated as in Fig. 15.

[0087] For embodiment 1, assuming that the cross-sectional area of the piston of the oil-well pump is: $S_{pistonA} = 54\times10^{-4}m^2$, and the cross-sectional area of the oil sucker rod is:

$$S_{rodA} = 5\times10^{-4} m^2$$

[0088] The acceleration of the fluid in the oil pipeline during the up stroke is:

$$a_{Aup} = a\frac{S_{pistonA}}{S} = a\frac{54\times10^{-4}}{60\times10^{-4}} = 0.9a$$

[0089] The increased tension of the oil pipeline is:

$$\Delta F_{Aup} = ma_{Aup} = 0.9ma = 0.9\times12000\times1 = 10800N$$

[0090] The acceleration of the fluid in the oil pipeline during the down stroke is:

$$a_{Adown} = a\frac{S_{rodA}}{S} = a\frac{5\times10^{-4}}{60\times10^{-4}} = 0.083a$$

[0091] The increased tension of the oil pipeline is:

$$\Delta F_{Adown} = ma_{Adown} = 0.083ma = 0.083\times12000\times1 = 996N$$

[0092] Then, the tension exerted on the main oil pipeline of embodiment 1 may be illustrated as Fig. 16.

[0093] As for embodiment 2, where the oil pumping system comprises two oil-well pump, and presuming that the total oil displacement is the same as that of embodiment 1, the cross-sectional area of the piston of the oil-well pump is: $S_{pistonB} = 27\times10^{-4}m^2$, and the cross-sectional area of oil sucker rod is: $S_{rodB} = 2.5\times10^{-4}m^2$

[0094] When the oil sucker rod 1 is in a up stroke, the oil sucker rod 2 is in a down stroke.

[0095] And when the first oil sucker rod 1 is in a down stroke, the second oil sucker rod 2 is in a up stroke; then

[0096] When the oil sucker rod accelerates, the acceleration of the fluid in the oil pipeline is:

$$a_B = a\frac{S_{pistonB} + S_{rodB}}{S} = a\frac{27\times10^{-4} + 2.5\times10^{-4}}{60\times10^{-4}} = 0.492a$$

[0097] The increased tension of the oil pipeline is:

$$\Delta F_B = ma_B = 0.492ma = 0.492\times12000\times1 = 5904N$$

[0098] Then, the tension exerted on the main oil pipeline of embodiment 2 may be illustrated as Fig. 17.

[0099] The oil pumping system of embodiment 3 comprises three oil-well pumps (for uniform reference, the number of the oil-well pump in this embodiment is referred to as "n"). When the total oil lifting capacity in this embodiment is equal to that in the embodiment 1, the oil lifting capacity of each oil-well pump in embodiment 3 is 1/n of that of the oil-well pump in embodiment 1 ;

[0100] Using the servo control unit to control each oil-well pump to accelerate at different time may significantly reduce the increased tension on the oil pipeline, in other words, the amplitude of the tension can be significantly reduced.

[0101]

$$\Delta F_C = \frac{2}{n}\Delta F_B$$

[0102] When n=4,

$$\Delta F_C = \frac{2}{4}\Delta F_B = 5904/2 = 2952N$$

[0103] The tension on the main oil pipeline is as shown in Fig. 18.

[0104] As shown in the above mentioned three diagrams, during the acceleration of the up and down stroke, the tension variation according to embodiment 2 is smaller than that of embodiment 1, and the tension variation of embodiment 3 is 2/n of that of embodiment 2. Therefore, if "n" is reasonably big, the tension variation according to embodiment 3 will be very small.

[0105] Assuming the elastic modulus of steel is: E = 200GPa

And assuming the cross-sectional area of the pipe is: $S_{pipe} = 10\times10^{-4}m^2$

Length difference of the oil pipeline due to the tension is: $\Delta L = \frac{\Delta F\times L}{E\times S_{\text{pipe}}}$

Embodiment 1: $\Delta L = \frac{\Delta F\times L}{E\times S_{pipe}} = \frac{10800\times2000}{200\times10^9\times10\times10^{-4}} = 0.108m$

Embodiment 2: $\Delta L = \frac{\Delta F\times L}{E\times S_{pipe}} = \frac{5904\times2000}{200\times10^9\times10\times10^{-4}} = 0.05904m$

Embodiment 3: $\Delta L = \frac{\Delta F\times L}{E\times S_{pipe}} = \frac{2952\times2000}{200\times10^9\times10\times10^{-4}} = 0.02952m$

[0106] The above comparison shows that the length difference of embodiment 3, ΔL, is the smallest. That is to say, under such condition, the vibration on the main oil pipeline is the smallest, so it has the longest lifetime. At the same time, according to embodiment 3, it is easier to improve the oil lifting capacity of the entire system.

[0107] The terms and expressions employed in the embodiments herein are used as terms of description and not of limitation, and there is no intention, in the use of such terms and expressions, of excluding any equivalents of the features shown and described (or portions thereof), and it is recognized that various modifications are possible within the scope of the claims. Other modifications, variations, and alternatives are also possible. Accordingly, the claims in this application are intended to cover all such equivalents.

Claims

1. A hydraulic cylinder comprising a hydraulic cylinder body, a piston and a first piston rod connected with said piston; said piston dividing the cylinder body into an upper chamber and a lower chamber;
wherein the said hydraulic cylinder further comprising a second piston rod, which is connected with the piston, and which extends out of the cylinder body in a direction opposite to that of the first piston rod; at least one oil inlet/outlet opening is set on said hydraulic cylinder body corresponding to the upper chamber and the lower chamber respectively.

2. A hydraulic cylinder according to claim 1, wherein said oil inlet/outlet openings of the hydraulic cylinder body are communicated with a hydraulic driving mechanism through a first hydraulic oil pipe and a second hydraulic oil pipe respectively.

3. An oil pumping unit comprises the hydraulic cylinder of claim 1 or claim 2 and a first oil-well pump; wherein the first piston rod of the hydraulic cylinder is connected with the oil sucker rod of the first oil-well pump, and the first oil-well pump is provided with an oil outlet.

4. An oil pumping unit according to claim 3, wherein it further comprises a second oil-well pump, the oil sucker rod of which is connected with the second piston rod of the hydraulic cylinder , and said second oil-well pump is provided with an oil outlet.

5. An oil pumping unit according to claim 3 or claim 4, wherein it further comprises a position sensor provided at the top farthest reach of the piston rod to limit the upward travel distance of the hydraulic cylinder, and a position sensor provided at the bottom farthest reach of the piston rod to limit the downward travel distance of the hydraulic cylinder.

6. An oil pumping unit according to claim 5, wherein each of said position sensor may be a contact sensor or a non-contact sensor.

7. An oil pumping unit according to claim 6, wherein said contact sensor is a limit switch.

8. An oil pumping unit according to claim 6, wherein said non-contact sensor is a hall sensor or an IR switch.

9. An oil pumping module comprising a control mechanism, a hydraulic driving mechanism and an oil pumping unit of any one of claims 3-8; wherein said oil pumping unit is connected to said hydraulic driving mechanism through a hydraulic oil pipe, and said hydraulic driving mechanism is connected to said control mechanism, said control mechanism controlling the operation of said hydraulic driving mechanism and said hydraulic driving mechanism driving the reciprocating movement of the piston of the hydraulic cylinder in the oil pumping unit, and the reciprocating operation of the oil sucker rod of the oil-well pump is thus realized.

10. An oil pumping module according to claim 9, wherein said hydraulic driving mechanism comprises a two-way pump and a motor connected to said two-way pump through a shaft coupling, and said two-way pump is connected with the first and second hydraulic oil pipe of the hydraulic cylinder of the oil pumping unit.

11. An oil pumping module according to claim 10, wherein a protector is attached to the output terminal of said motor, said protector is filled up with insulating oil and is communicated to the interior of the motor.

12. An oil pumping module according to claim 9, wherein said two-way pump is a gear pump and said motor is an AC servo motor.

13. An oil pumping module according to claim 9, wherein said control mechanism is connected to the equipments above ground through a cable, the end of the cable for connecting with the control mechanism is a pressure-endurable and airtight cable connector.

14. An oil pumping module according to claim 13, wherein one end of said cable connector is the cable end and the other end is the control wiring end; wherein the cable joins the cable end of the cable connector and their junction is sealed through glue-potting; the wiring of the control mechanism is inserted into the wiring opening of the control wiring end of the cable connector and is sealed and said cable connector is fixed to the control mechanism with a flange.

15. An oil pumping module according to claim 9, wherein it further comprises an airtight housing body having an oil inlet opening; the oil-well pump is communicated with the oil in the exterior of the housing body through an oil inlet pipe that is connected with said oil inlet opening.

16. An oil pumping module according to claim 15, wherein the oil-well pump transports oil through an separate interim oil transmission pipe that is connected with its oil outlet.

17. An oil pumping module according to claim 15, wherein said housing body is provided with an oil outlet opening at an appropriate position such that the oil discharged from the oil-well pump inside of the housing body can be carried to outside.

18. An oil pumping system comprising one or a plurality of the oil pumping module according to any one of the claims 9-17; wherein each said oil pumping module is connected with the final oil outlet through an oil pipe that is connected with the oil outlet opening in the pumping module.

19. An oil pumping system according to claim 18, wherein each said oil pumping module is connected to another one through a connection means; said connection means may be a threaded screw or a flange.

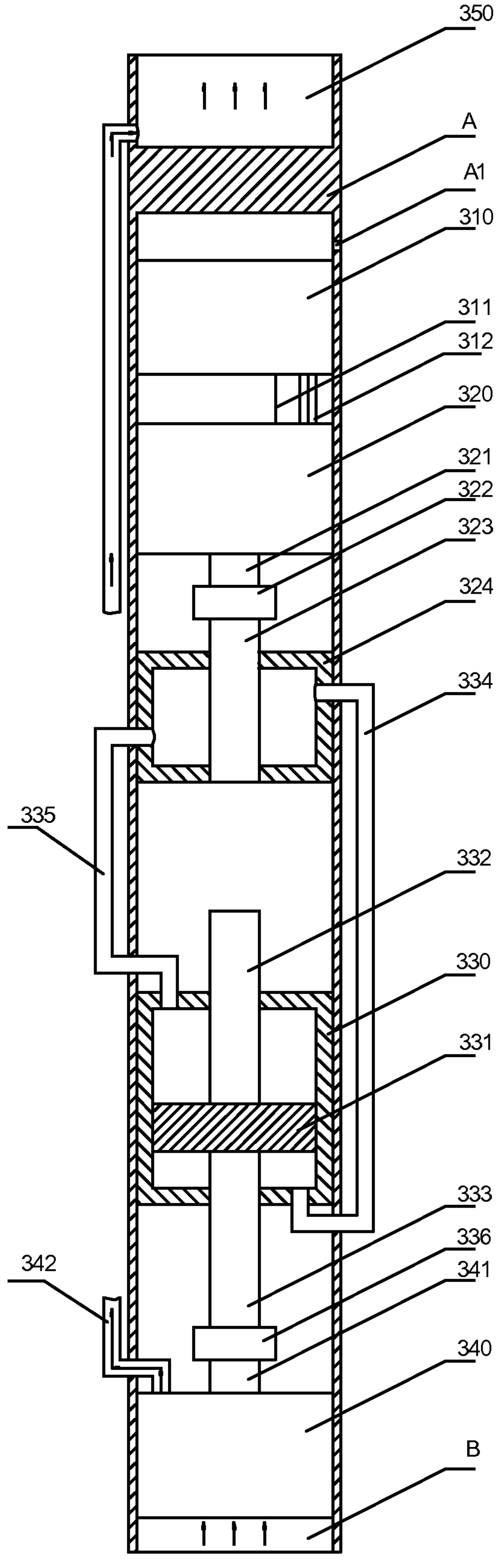
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Fig.1

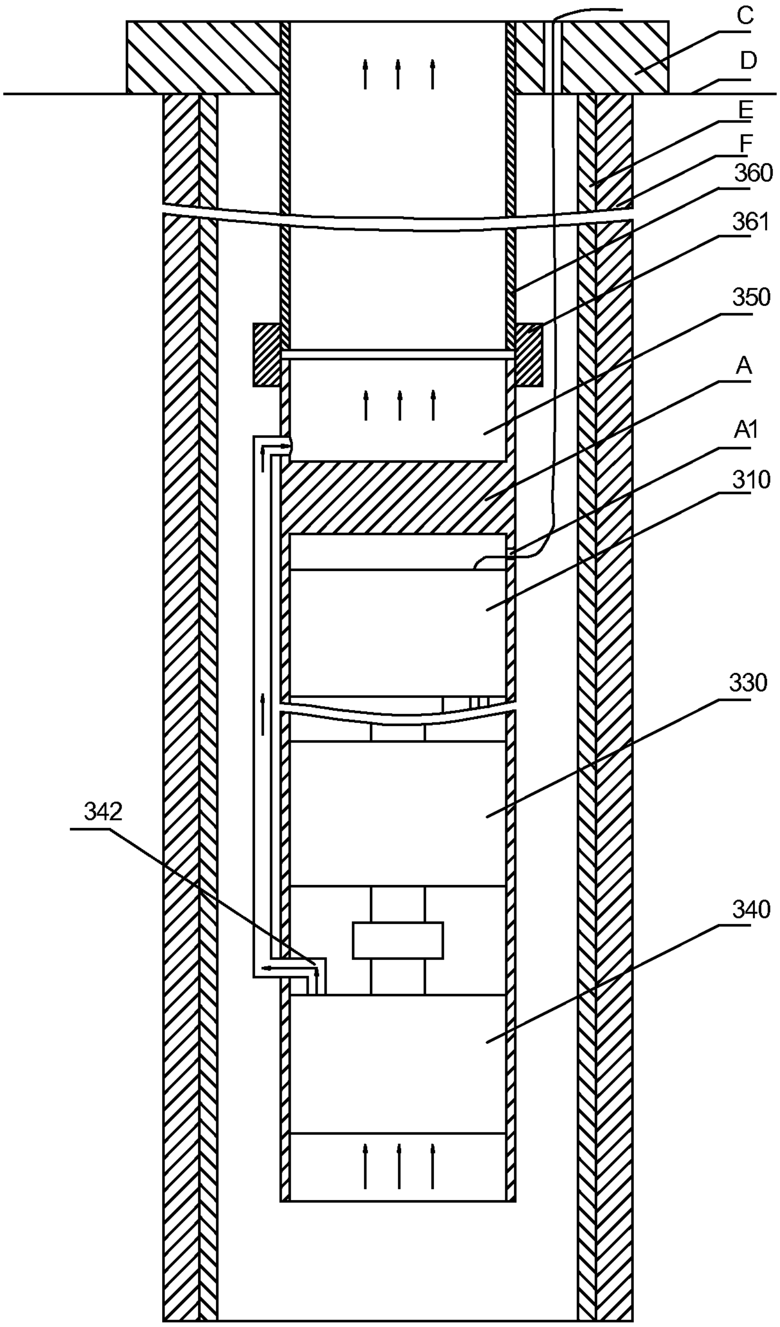

Fig.2

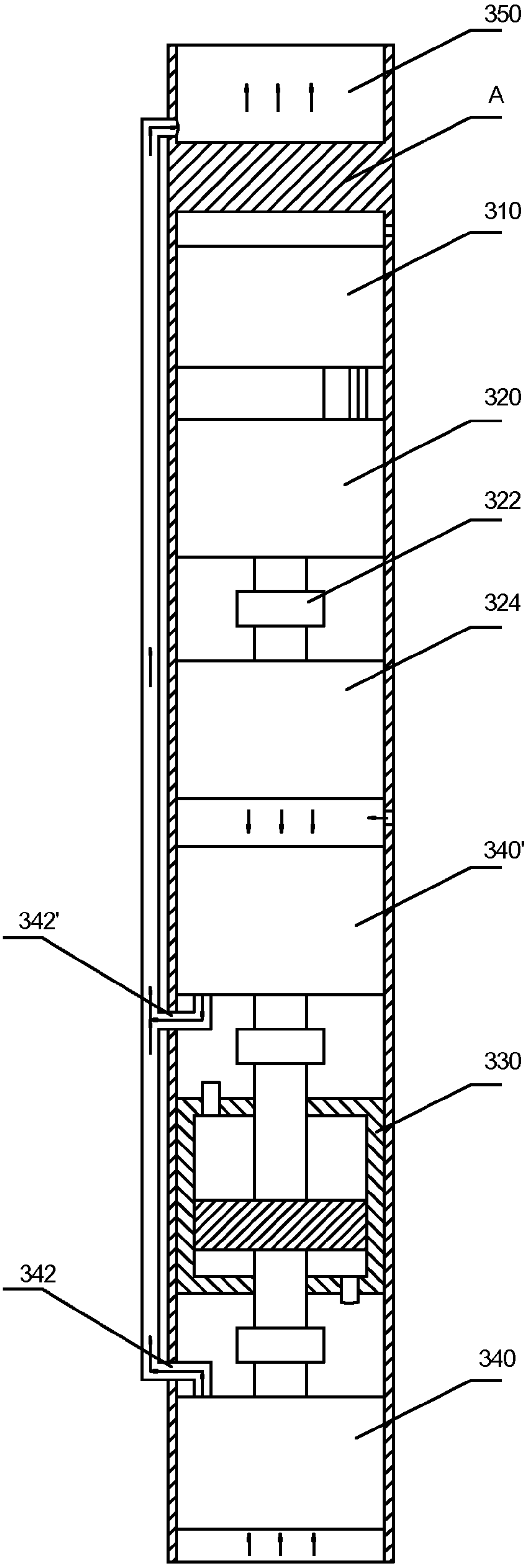

Fig.3

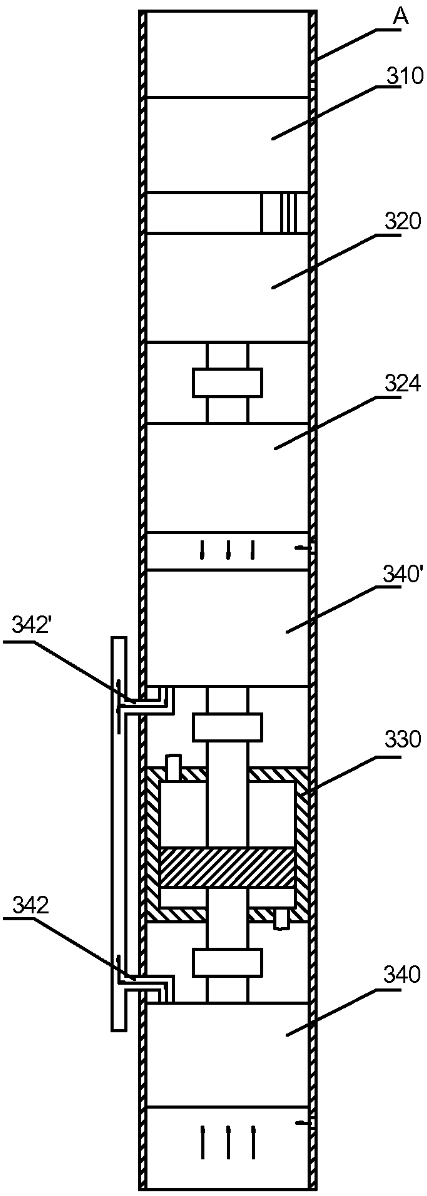

Fig.4

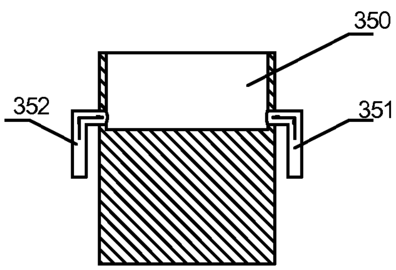

Fig.5

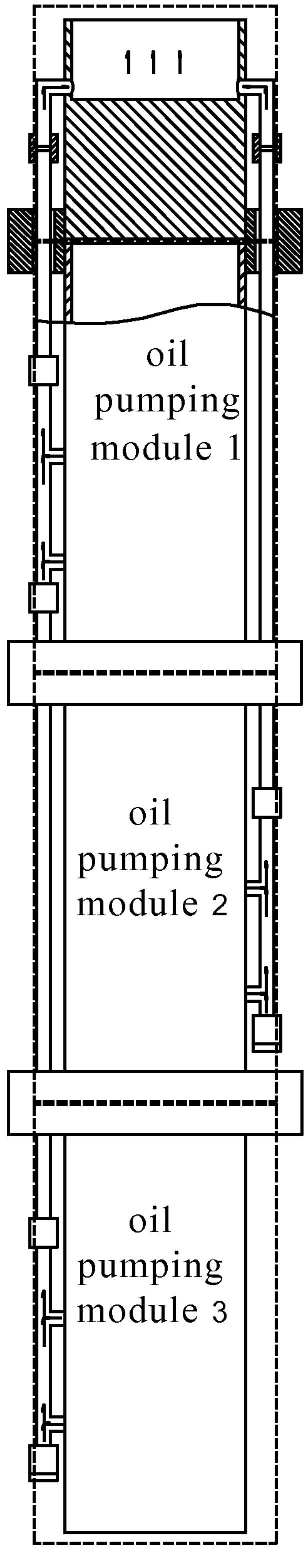

Fig.6

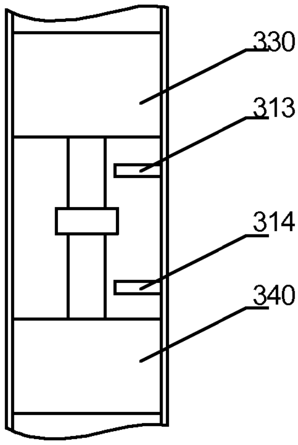

Fig.7

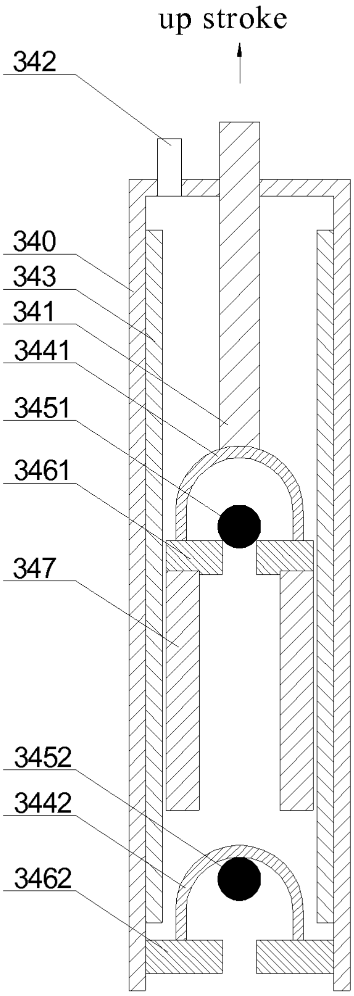

Fig.8

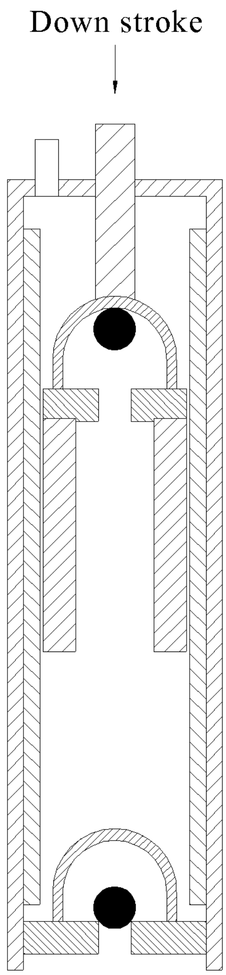

Fig.9

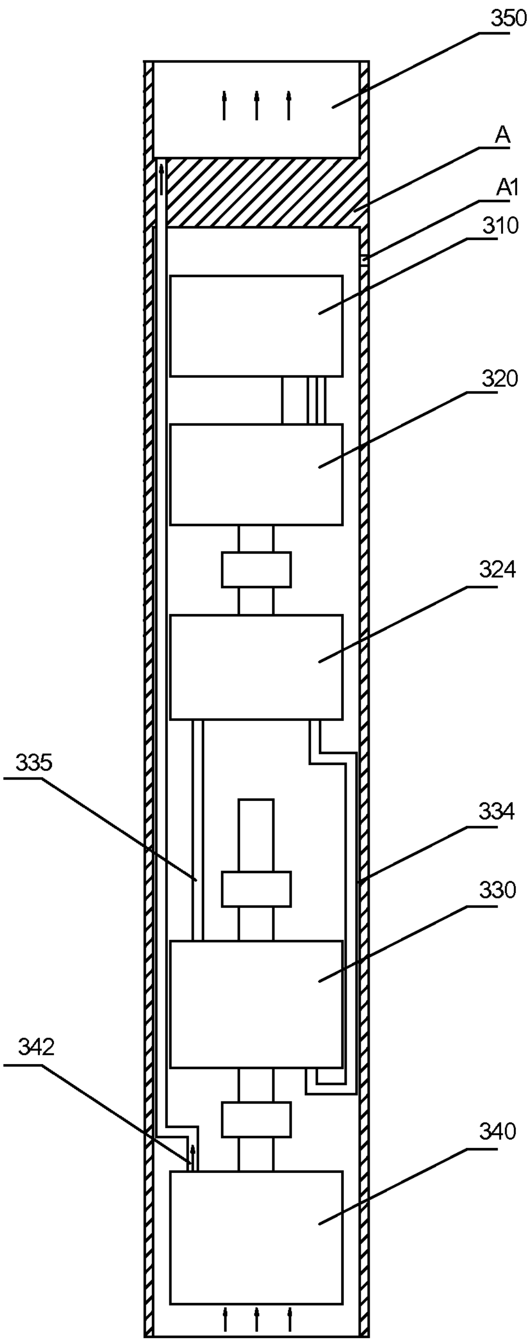
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Fig.10

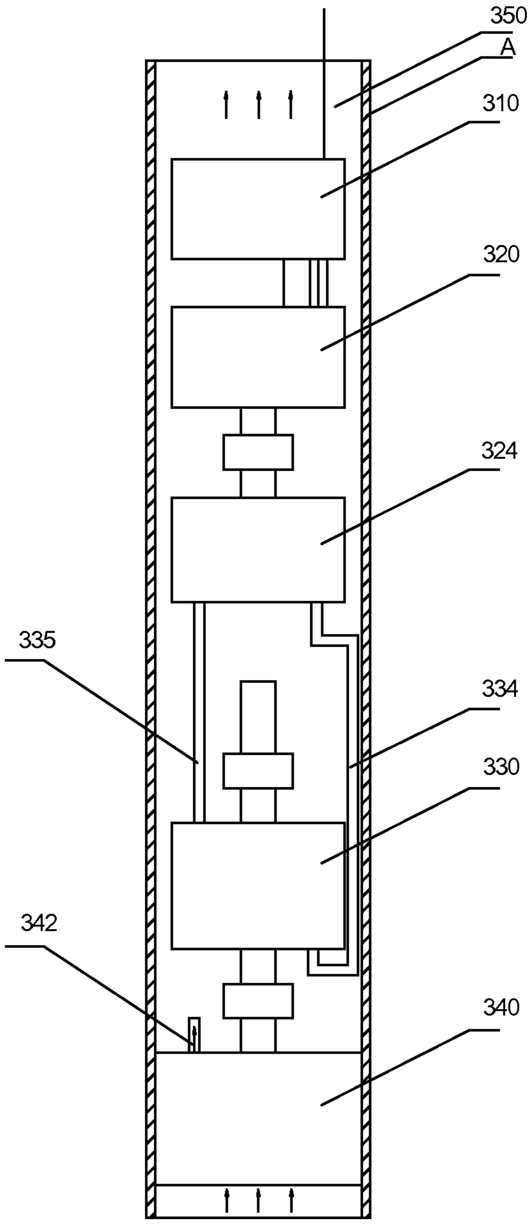
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Fig.11

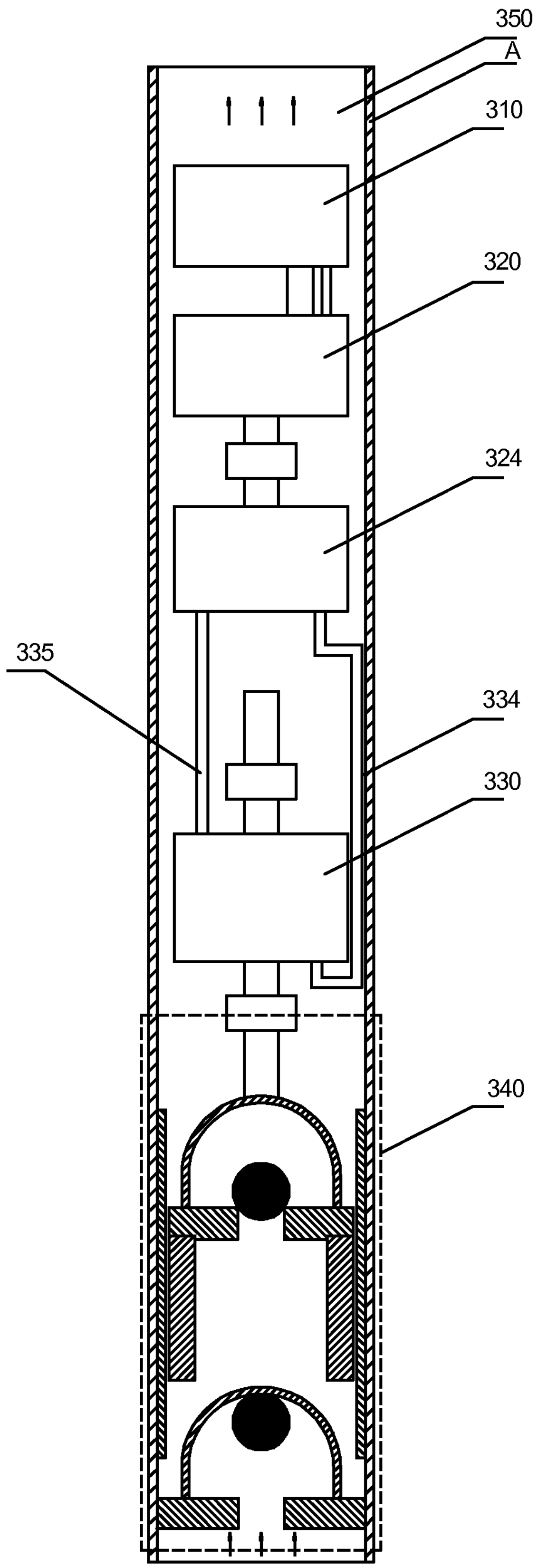

Fig.12

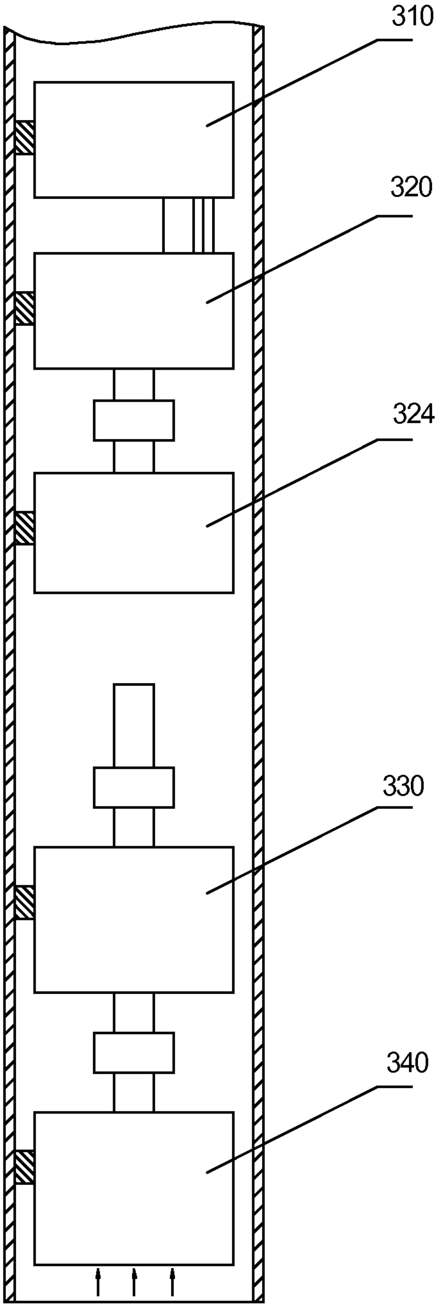

Fig.13

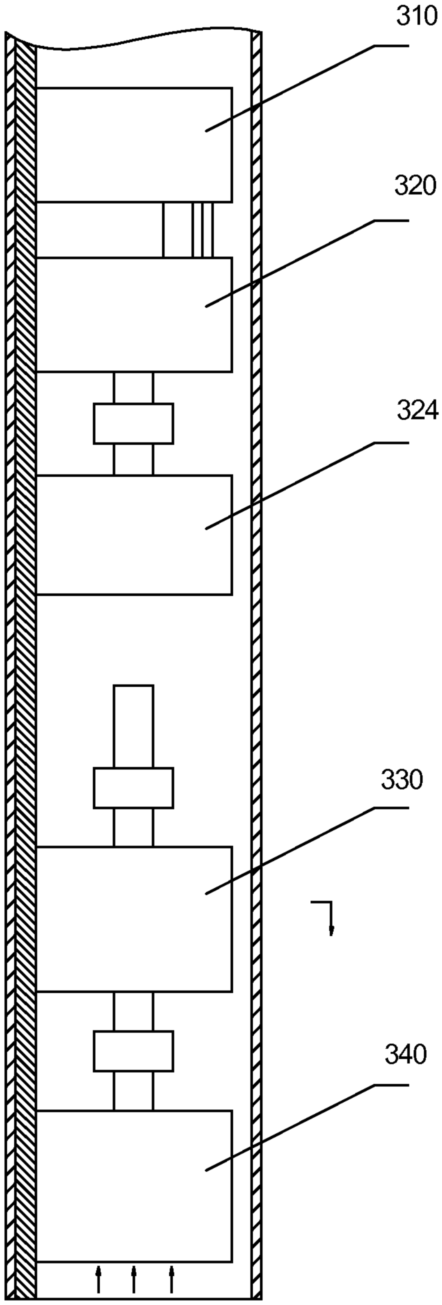

Fig.14

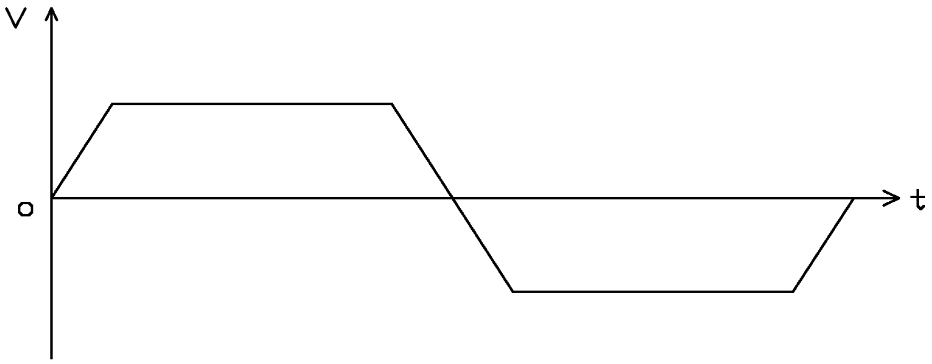

Fig.15

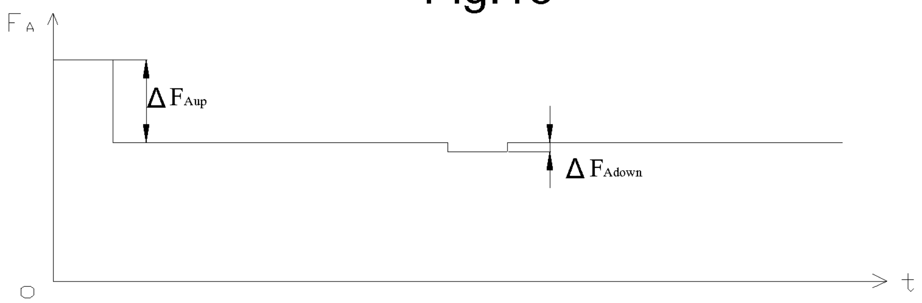

Fig.16

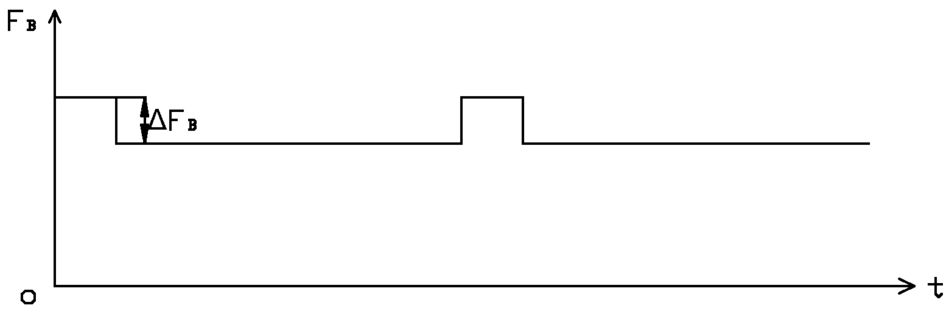

Fig.17

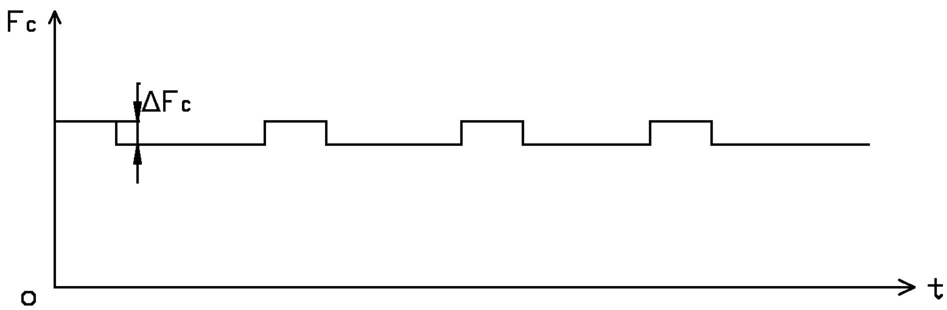

Fig.18

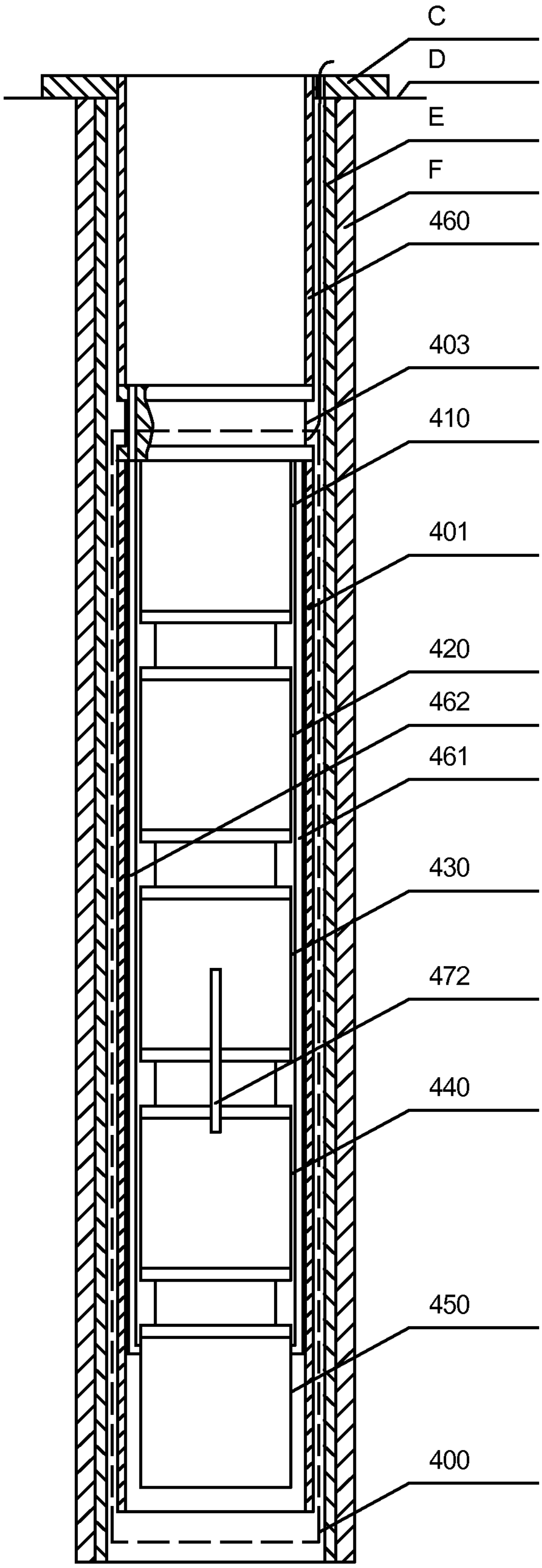

Fig.19

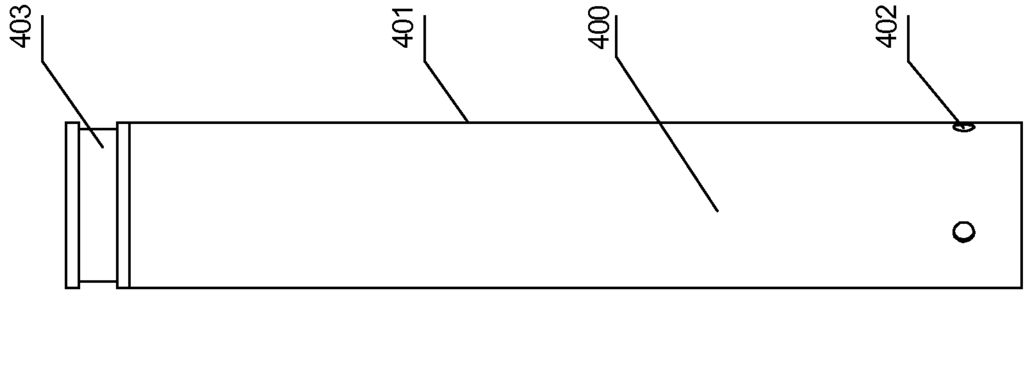

Fig.20

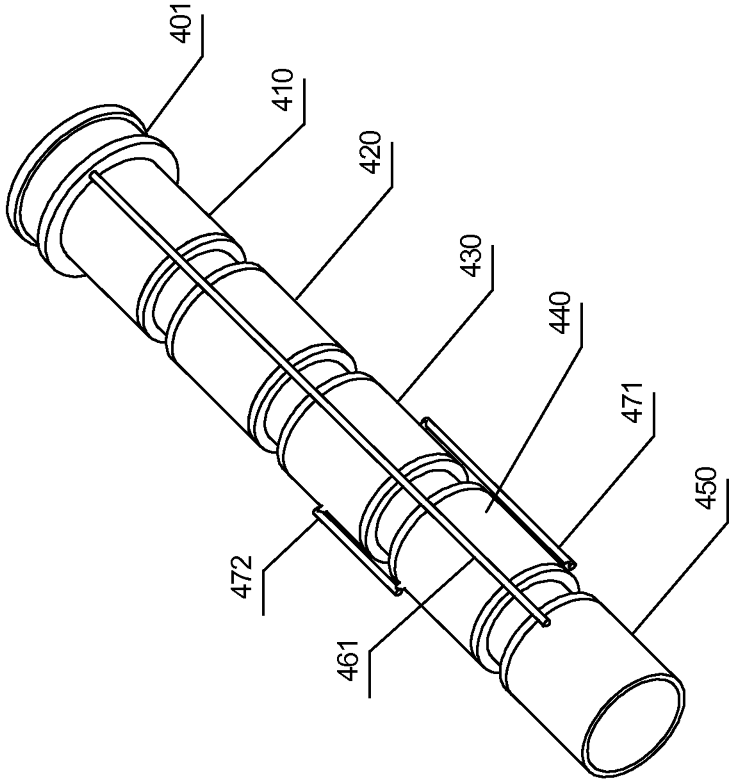

Fig.21

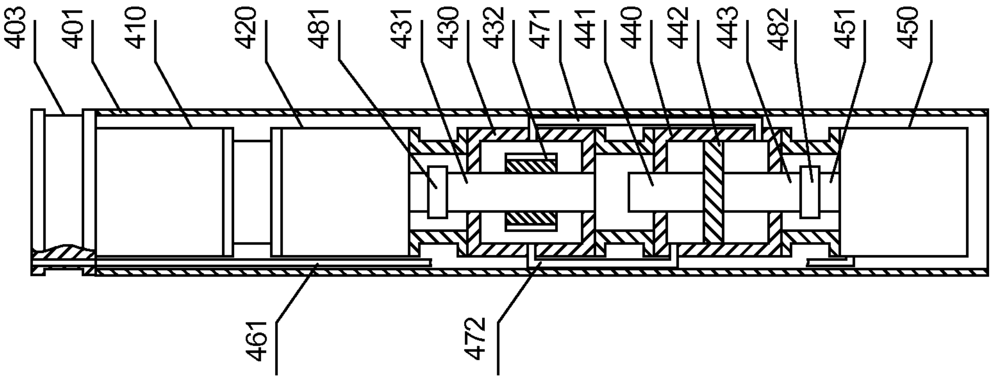

Fig.22

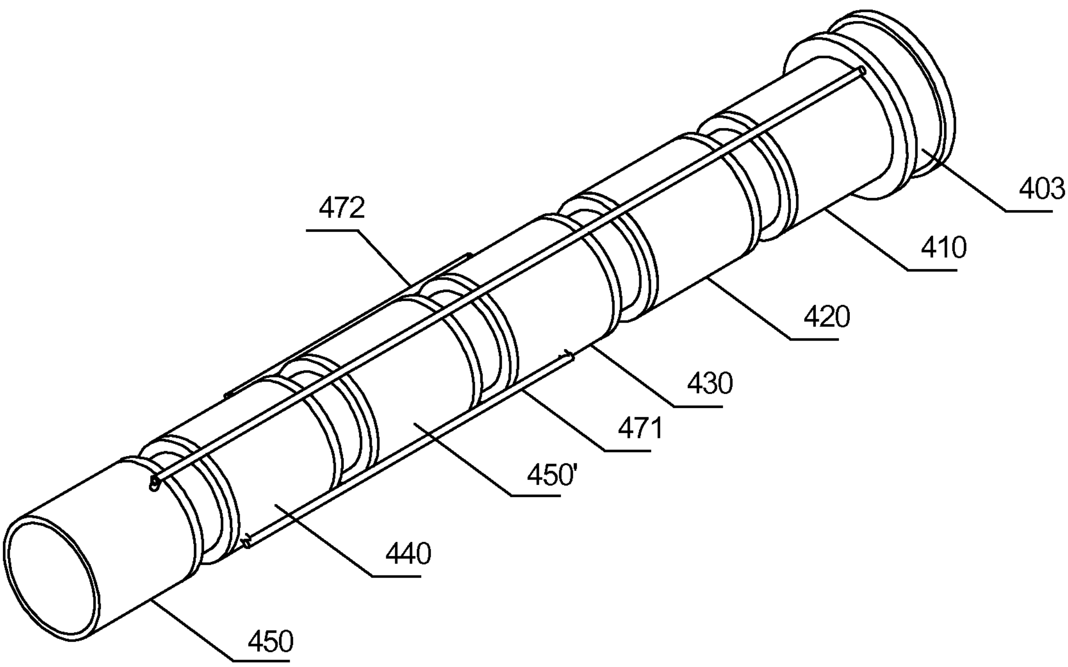

Fig.23

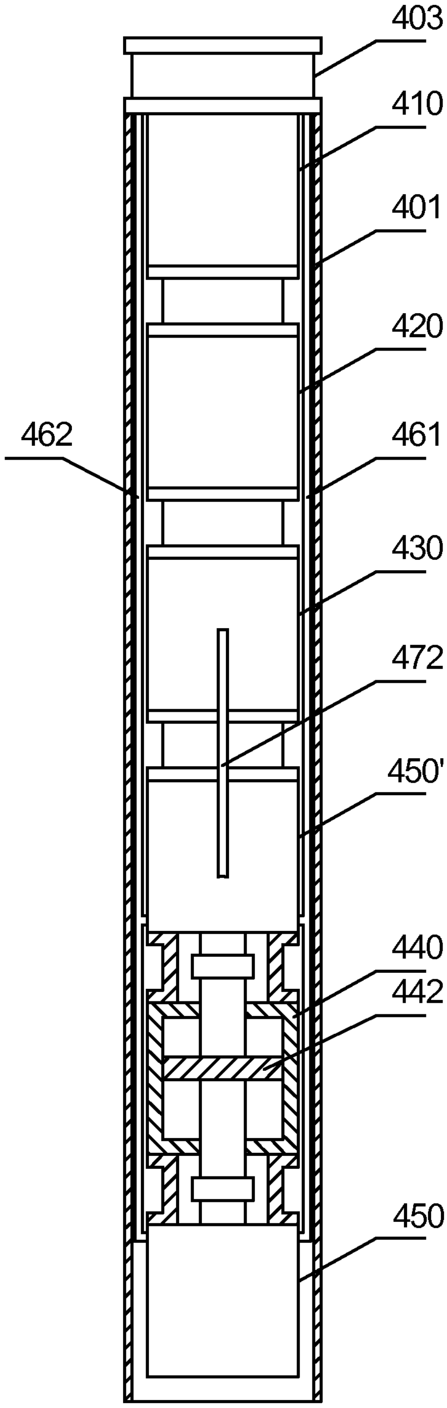

Fig.24

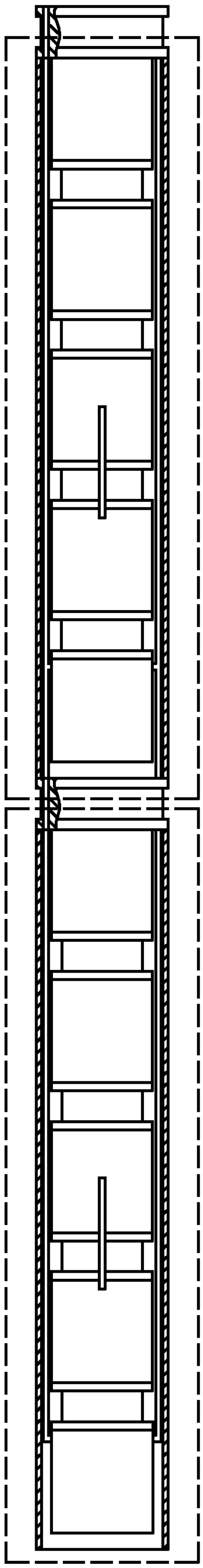

Fig.25

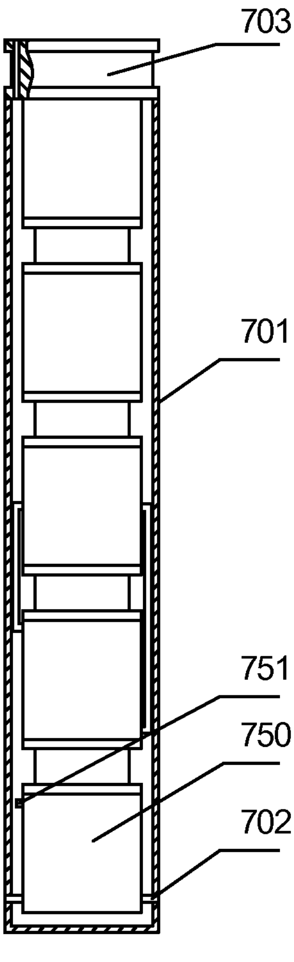

Fig.26

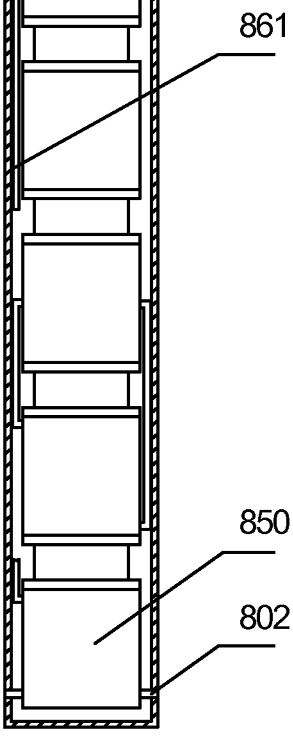

Fig.27

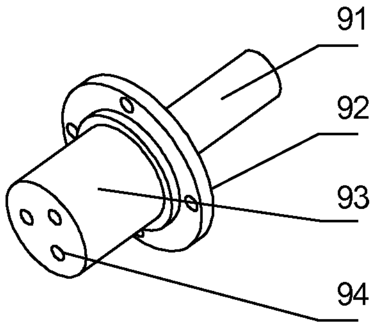

Fig.28

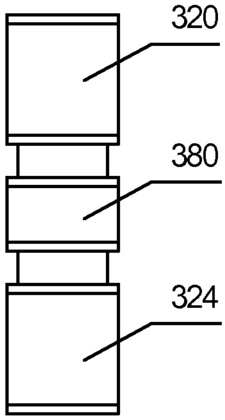

Fig.29

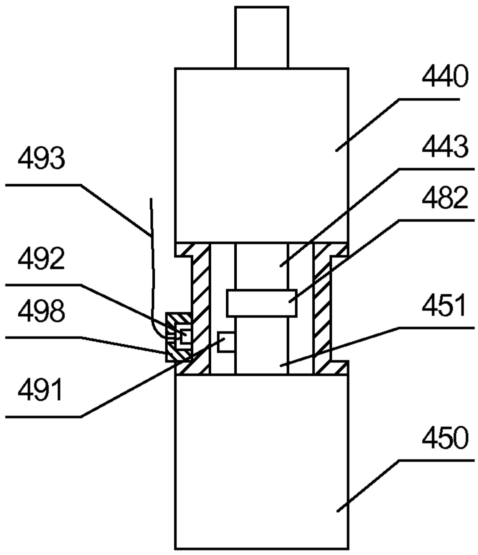

Fig.30

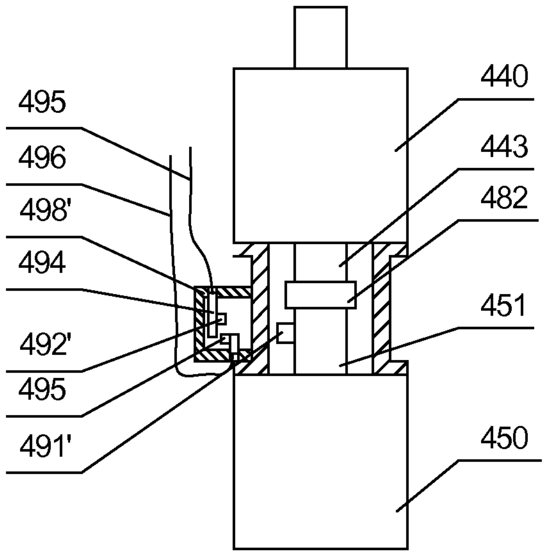

Fig.31

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2009/070688

A. CLASSIFICATION OF SUBJECT MATTER

See the extra sheet

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: F04B, E21B, F15B, F16J

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)

EPODOC, WPI, PAJ, CNPAT, CNKI: hydraulic, bidirectional, dual, two, second, opposite, pump+, piston?, plunger?, rod?, lever?

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	CN1773116A (CHEN, Changan) 17 May 2006 (17.05.2006) page 2, lines 10-16, fig.2	1-19
PX	CN201165964Y (HAO, Shuanghui) 17 Dec.2008 (17.12.2008) claims 1-10, figs. 1-14	1-19
X	CN2301552Y (GONG, Xin) 23 Dec.1998 (23.12.1998) abstract, fig.1	1-19
X	JP2006-161844A (KAYABA INDUSTRY CO LTD) 22 Jun.2006 (22.06.2006) abstract, figs.1-4	1-19
X	JP2006-153113A (MITSUBISHI HEAVY IND LTD) 15 Jun.2006 (15.06.2006) abstract, figs.1-4	1-19
X	JP2006-153063A (KAYABA INDUSTRY CO LTD) 15 Jun.2006 (15.06.2006) abstract, fig.1	1-19

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

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim (S) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
06 May 2009 (06.05.2009)	**28 May 2009 (28.05.2009)**

Name and mailing address of the ISA/CN	Authorized officer
The State Intellectual Property Office, the P.R.China 6 Xitucheng Rd., Jimen Bridge, Haidian District, Beijing, China 100088 Facsimile No. 86-10-62019451	JIAO, Hongfang Telephone No. (86-10)62085408

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2009/070688

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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A	CN1124824A (HU, Junwei et al.) 19 Jun.1996 (19.06.1996) the whole document	1-19

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International application No.
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INTERNATIONAL SEARCH REPORT

International application No.
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A. CLASSIFICATION OF SUBJECT MATTER:

F04B 47/00 (2006.01)i
E21B 43/00 (2006.01)i
F04B 49/06 (2006.01)i
F04B 5/02 (2006.01)i
F15B 11/02 (2006.01)i

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更正页

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