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(54) **JET PUMP LIFT SYSTEM FOR PRODUCING HYDROCARBON FLUIDS**

(57) A jet pump lift system for use with a tubing (110) disposed in a casing (115) includes a jet pump (120) installed in the tubing; a one way valve (160) for communicating a power fluid into the jet pump; and a safety valve (180) configured to block fluid communication through the tubing and disposed above the jet pump.

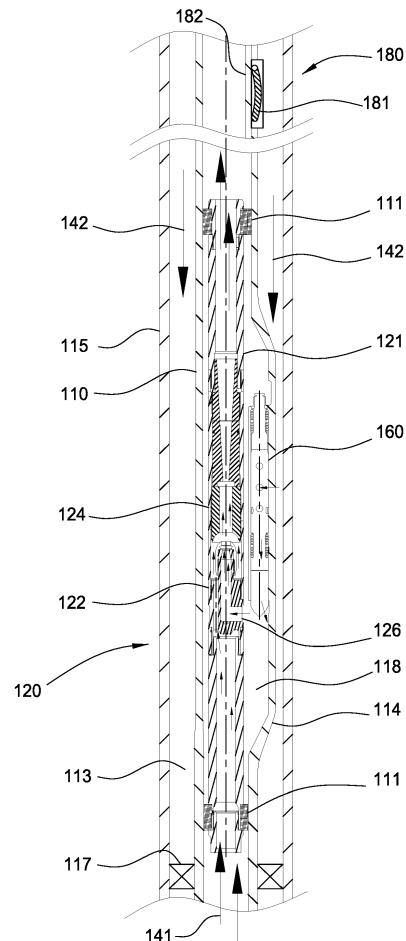


FIG. 2

Description

BACKGROUND OF THE INVENTION

Field of the Invention

[0001] Embodiments of the present invention generally relate to artificially lifting fluid from a wellbore. More particularly, embodiments of the present invention relate to artificially lifting fluid from a wellbore using a jet pump lift system.

Description of the Related Art

[0002] To obtain hydrocarbon fluids from an earth formation, a wellbore is drilled into the earth to intersect an area of interest within a formation. The wellbore may then be "completed" by inserting casing within the wellbore and setting the casing therein using cement. In the alternative, the wellbore may remain uncased (an "open hole wellbore"), or may become only partially cased. Regardless of the form of the wellbore, production tubing is typically run into the wellbore primarily to convey production fluid (e.g., hydrocarbon fluid, which may also include water) from the area of interest within the wellbore to the surface of the wellbore.

[0003] Often, pressure within the wellbore is insufficient to cause the production fluid to naturally rise through the production tubing to the surface of the wellbore. Thus, to carry the production fluid from the area of interest within the wellbore to the surface of the wellbore, artificial lift means is sometimes necessary.

[0004] Some artificially-lifted wells are equipped with sucker rod lifting systems. Sucker rod lifting systems generally include a surface drive mechanism, a sucker rod string, and a downhole positive displacement pump. Fluid is brought to the surface of the wellbore by pumping action of the downhole pump, as dictated by the drive mechanism attached to the rod string.

[0005] One type of sucker rod lifting system is a rotary positive displacement pump, typically termed a progressive cavity pump ("PCP"). The progressive cavity pump lifts production fluid by a rotor disposed within a stator. The rotor rotates relative to the stator by use of a sucker rod string.

[0006] An additional type of sucker rod lifting system is a rod lift system, with which fluid is brought to the surface of the wellbore by reciprocating pumping action of the drive mechanism attached to the rod string. Reciprocating pumping action moves a traveling valve on the positive displacement pump, loading it on the downstroke of the rod string and lifting fluid to the surface on the upstroke of the rod string.

[0007] Sucker rod lifting systems include several moving mechanical components. Specifically, the rod strings of sucker rod lifting systems must be reciprocated or rotated to operate the lifting systems. In some applications, the moving parts are disadvantageous. When a subsur-

face safety valve is employed within the wellbore, such as within an offshore well, a sucker rod string cannot be placed through the subsurface safety valve. Additionally, moving parts are susceptible to failure or damage, potentially causing the sucker rod lifting systems to become inoperable.

[0008] An alternative lift system involves using a jet pump. As shown in Figure 1, a production tubing 10 having a jet pump 20 is installed in a casing 15. The jet pump 20 includes a nozzle section, a venturi section, and inlet ports in fluid communication with the venturi section. A ported sub 22 fluidly connects the bottom of the venturi section with the annular area between the tubing 10 and the casing 15. Production fluid flowing up the tubing 10 can flow into the venturi section via the inlet ports.

[0009] In operation, power fluid is directed down the tubing 10 toward the nozzle section of the jet pump 20. Power fluid exiting the nozzle section is directed through the venturi section. As the power fluid passes from the nozzle section to the venturi section, production fluid is drawn into the venturi section via the inlet ports. The combined power fluid and production fluid leave the venturi section via the ported sub 22 and enter the annular area, where the combined fluids flow upward to the surface.

[0010] In many of these operations, a safety valve is attached to a landing nipple 23 disposed below the jet pump 20. The safety valve serves as a safety barrier for both the tubing 10 and the casing 15 by blocking communication through the bore of the tubing 10. In some instances, the jet pump is installed at depths of 8,000 ft. or more. Because the safety valve is below the jet pump, the safety valve must be rated for use at these depths. The safety valves required for these depths are usually much more expensive than safety valves rated for use at shallower depths; in some instances, more than double or triple the costs. The cost associated with control lines for operating the safety valves also increase with depth.

[0011] There is, therefore a need for an improved lift system for producing hydrocarbon fluids. There is also need for a lift system that allows a safety valve to be installed above a jet pump.

SUMMARY OF THE INVENTION

[0012] In one embodiment, a jet pump lift system for use with a tubing disposed in a casing includes a jet pump installed in the tubing; a one way valve for communicating a power fluid into the jet pump; and a safety valve configured to block fluid communication through the tubing and disposed above the jet pump.

[0013] In another embodiment, a method of producing hydrocarbon fluids includes installing a jet pump in a production tubular; maintaining a safety valve located above the jet pump in an open position; supplying a power fluid through a one way valve and into the jet pump; urging a production fluid into the jet pump; and flowing the production fluid and the power fluid past the safety valve.

BRIEF DESCRIPTION OF THE DRAWINGS

[0014] So that the manner in which the above recited features of the present invention can be understood in detail, a more particular description of the invention, briefly summarized above, may be had by reference to embodiments, some of which are illustrated in the appended drawings. It is to be noted, however, that the appended drawings illustrate only typical embodiments of this invention and are therefore not to be considered limiting of its scope, for the invention may admit to other equally effective embodiments.

Figure 1 shows a prior art artificial lift system using a jet pump.

Figure 2 shows an exemplary artificial lift system using a jet pump and a one way valve.

Figure 2A is an enlarged partial view of the lift system of Figure 2.

Figure 3 illustrates an exemplary embodiment of a one way valve.

DETAILED DESCRIPTION

[0015] Embodiments of the present disclosure relate to an artificial lift system using a jet pump and a one-way valve for fluid communication between the jet pump and a power fluid source. In one aspect, the jet pump driven system advantageously allows a safety valve to be installed above the jet pump.

[0016] Figure 2 shows an exemplary artificial lift system for producing a hydrocarbon fluid. Figure 2A is an enlarged partial view of Figure 2. A jet pump 120 is installed in a production tubing 110 disposed in a casing 115. A packer 117 blocks the annular area between the tubing 110 and the casing 115 below the jet pump 120.

[0017] The jet pump 120 includes a tubular housing 121 having an inlet located at a lower end and an outlet located at an upper end. The outer surface of the two ends of the tubular housing 121 sealingly engages the inner surface of the bore of the tubing 110. In this respect, production fluid flowing up the bore is directed into the inlet of the housing 121. In one embodiment, the ends may be sealed using one or more sealing members 111 such as o-rings and chevron seals.

[0018] An annular chamber 118 is defined between the two sealed ends and between the tubing 110 and the housing 121 of the jet pump 120. A one way valve 160 is used to control fluid communication between the annular chamber 118 and the annular area 113 between the tubing 110 and the casing 115. The one way valve 160 is configured to allow fluid in the annular area 113 to flow into the annular chamber 118. In this respect, the one way valve 160 prevents pressure increases, such as a blow-out condition, from being communicated into

the casing 115. An exemplary one way valve is a check valve. It is contemplated that a single or a plurality of one way valves may be used to communicate fluid into the annular chamber 118. In one example, the one way valve 160 can be located at any location between the jet pump and the power fluid source. In another example, the one way valve 160 is located below the valve 180, as shown in Figure 2. In yet another example, the one way valve 160 is located at a depth between 6,000 ft. and 30,000 ft., such as between 8,000 ft. and 20,000 ft. In a further example, the one way valve is located at a depth between 6,000 ft. and the depth of perforation.

[0019] In one embodiment, the jet pump 120 is installed in a tubing 110 having a side pocket mandrel 114, as disclosed in U.S. Patent No. 7,228,909, which patent is incorporated by reference, in particular, Figures 1, 2A, 2B, 3, and 5, and the corresponding description.

[0020] Figure 3 illustrates an exemplary embodiment of a one way valve 335 suitable for use with a side pocket of the tubing. The one way valve 335 includes a tubular body 305 having a generally longitudinal central bore 336 therethrough and having an upper end 301 and a lower end 302. The lower end 302 includes an outlet port 313 for ejecting fluid from the bore 336, and the upper end 301 includes a connector for connecting the one way valve to a latching mechanism for retrieval. The tubular body 305 includes two inlet ports 331 A, 331 B fluidly connecting the central bore 336 to the outside of the one way valve 335. Seal assemblies 328, 329 form a seal path for the fluid to enter the inlet ports 331 A, 331 B. A first ball and seat mechanism 340 is used to control fluid communication between the inlet ports 331A, 331 B and the bore 336. When the fluid outside the one way valve 335 reaches a predetermined level, the ball will be urged away from the seat, thereby allowing fluid, such as power fluid P, to flow into the bore 336. A second ball and seat mechanism 350 is disposed in the body 305 between the first ball and seat mechanism 340 and the outlet port 313. The second ball and seat mechanism 350 allows fluid flow from the inlet ports 331 A, 331 B to the outlet port 350, but does not allow fluid flow in the opposite direction.

[0021] Referring back to Figures 2 and 2A, the jet pump 120 includes a nozzle section 122 spaced apart from a venturi section 124. The spaced area 125 between the nozzle section 122 and the venturi section 124 fluidly communicates with the bore of housing 121. This arrangement allows fluid flowing through the inlet of the housing 121 to flow toward the venturi section 124. A side port 126 formed in the tubular housing 121 provides fluid communication between the annular chamber 118 and the interior of the nozzle section 122. The nozzle section 122 includes a throat 128 having an inwardly tapered portion that increases the velocity of the power fluid flowing out of the nozzle section 122. The venturi section 124 is configured to receive power fluid from the nozzle section 122 and the production fluid. The venturi section 124 includes an outwardly tapered portion 129 that increases the pressure of the combined fluids flowing

out of the venturi section 124 while decreasing the velocity of the combined fluids. Exemplary power fluids include water, oil, hydrocarbon, and combinations thereof.

[0022] A safety valve 180 is installed in the tubing 110 and above the jet pump 120. In one embodiment, the safety valve 180 includes a flapper 181 movable between an open position and a closed position. The flapper 181 is operated by a flow tube 182 controlled by a control line. As shown, the flapper 181 is maintained in the open position by the flow tube 182. To close the flapper 181, pressure is supplied through the control line to move the flow tube 182 upward, thereby freeing the flapper 181 to pivot into the bore of the tubing 110 to block fluid communication through the bore. To open the flapper 181, pressure is supplied through the control line to move the flow tube 182 downward, thereby pivoting the flapper 181 away from the bore to open fluid communication through the bore.

[0023] In operation, production fluid 141 in the tubing 110 flows upward and enters the jet pump 120 via the inlet of the tubular housing 121. Power fluid 142 is supplied down the annular area 113 between the tubing 110 and the casing 115 toward the jet pump 120. The power fluid 142 then passes through the one way valve 160 and enters the annular chamber 118. The power fluid 142 flows through the side port 126 toward the throat 128 of the nozzle section 122. As the power fluid 142 is forced through the throat 128, the velocity of the power fluid 142 is increased. The power fluid 142 exiting the throat 128 passes through the spaced area 125 and enters the venturi section 124. As the power fluid passes from the nozzle section 122 to the venturi section 124, production fluid 141 in the spaced area 125 is drawn into the venturi section 124. The combined fluids 141, 142 then flow through the outwardly tapered portion 129, where the velocity of the combined fluids is decreased and the pressure is increased. The combined fluids 141, 142 flows out of the jet pump 120 and up the tubing 110. The flapper 181 is retained in the open position to allow the combined fluids 141, 142 to flow to the surface.

[0024] As discussed, embodiments of the jet pump lift system advantageously allow the safety valve to be installed above the jet pump. Because the one way valve prevents fluid communication from the tubing 110 into annular area 113 with the casing 115, the safety valve only needs to block fluid communication up the tubing 110. In one example, the safety valve is located at 3,000 ft. or above, such as between 200 ft. and 2,500 ft., between 1,000 ft. and 2,000 ft., and 2,000 ft. or above. Safety valves rated for these depths cost substantially less than safety valves rated for much lower depths, such as between 8,000 ft. and 20,000 ft.

[0025] Any directional terms used in the description above are merely illustrative, for example, the terms "upward", "downward", etc., and not limiting. It is understood that the production tubing described above is usable with in any orientation of wellbore, including but not limited to a vertical, horizontal, directionally-drilled, or lateral well-

bore.

[0026] While the foregoing is directed to embodiments of the present invention, other and further embodiments of the invention may be devised without departing from the basic scope thereof, and the scope thereof is determined by the claims that follow.

Claims

1. A jet pump lift system for use with a tubing disposed in a casing, comprising:
 - a jet pump installed in the tubing;
 - a one way valve for communicating a power fluid into the jet pump; and
 - a safety valve configured to block fluid communication through the tubing and disposed above the jet pump.
2. The system of claim 1, wherein the one way valve comprises a check valve.
3. The system of claim 1 or 2, wherein the safety valve comprises a flapper valve.
4. The system of any preceding claim, wherein the one way valve allows fluid communication from an annular area between the tubing and the casing to the jet pump.
5. The system of any preceding claim, wherein the one way valve is positioned below the safety valve.
6. The system of any preceding claim, wherein the safety valve is positioned at a depth of 3,000 ft. or less.
7. The system of any preceding claim, wherein the one way valve is positioned at a depth of 6,000 ft. or more.
8. The system of any preceding claim, further comprising an annular packer located below the one way valve.
9. The system of any preceding claim, wherein the one way valve is installed in a side pocket of the tubing.
10. A method of producing hydrocarbon fluids, comprising:
 - installing a jet pump in a production tubular;
 - maintaining a safety valve located above the jet pump in an open position;
 - supplying a power fluid through a one way valve and into the jet pump;
 - urging a production fluid into the jet pump; and
 - flowing the production fluid and the power fluid past the safety valve.

11. The method of claim 10, wherein the production tubular is disposed in a casing, and the power fluid is supplied down an annular area between the production tubular and the casing. 5
12. The method of claim 11, wherein the one way valve controls power fluid flow into the production tubular.
13. The method of any of claims 10 to 12, wherein the power fluid flows into the jet pump via a side port. 10
14. The method of any of claims 10 to 13, wherein the safety valve comprises a flapper valve.
15. The method of any of claims 10 to 14, wherein the one way valve comprises a check valve. 15
16. The method of any of claims 10 to 15, wherein the safety valve is located a depth of 3,000 ft. or less. 20

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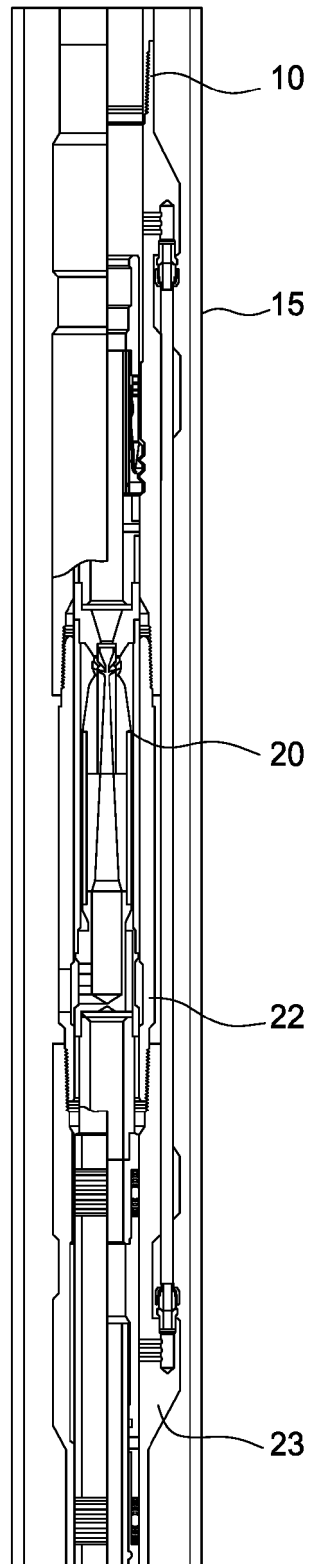


FIG. 1
(PRIOR ART)

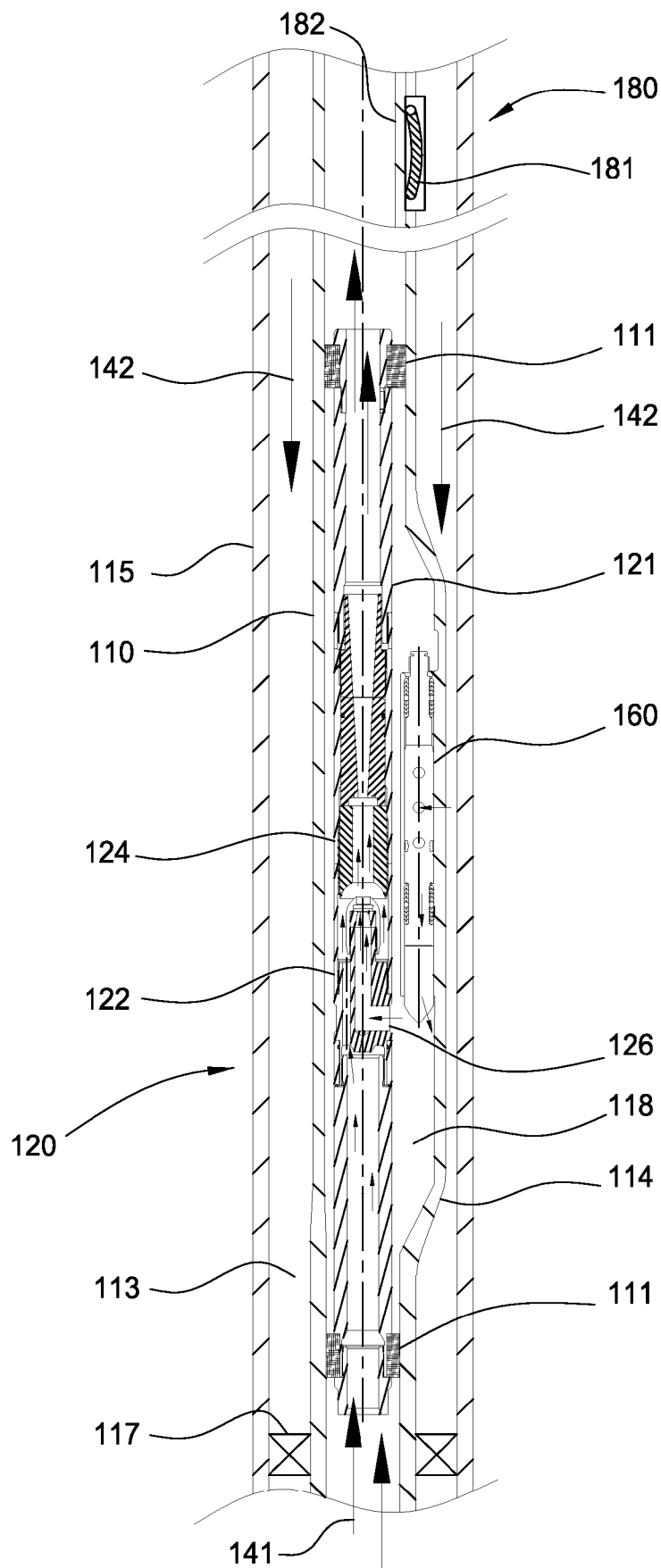


FIG. 2

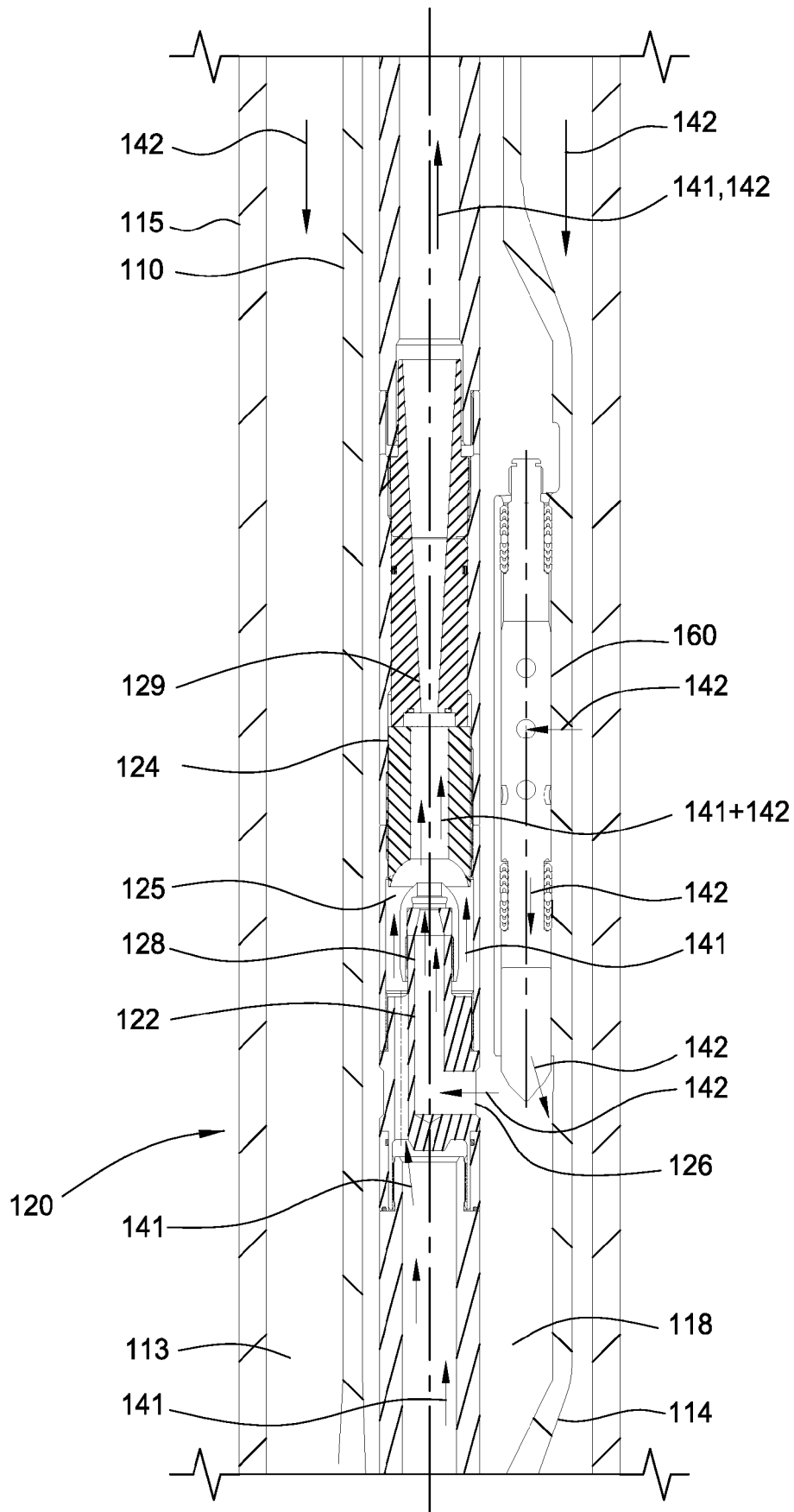


FIG. 2A

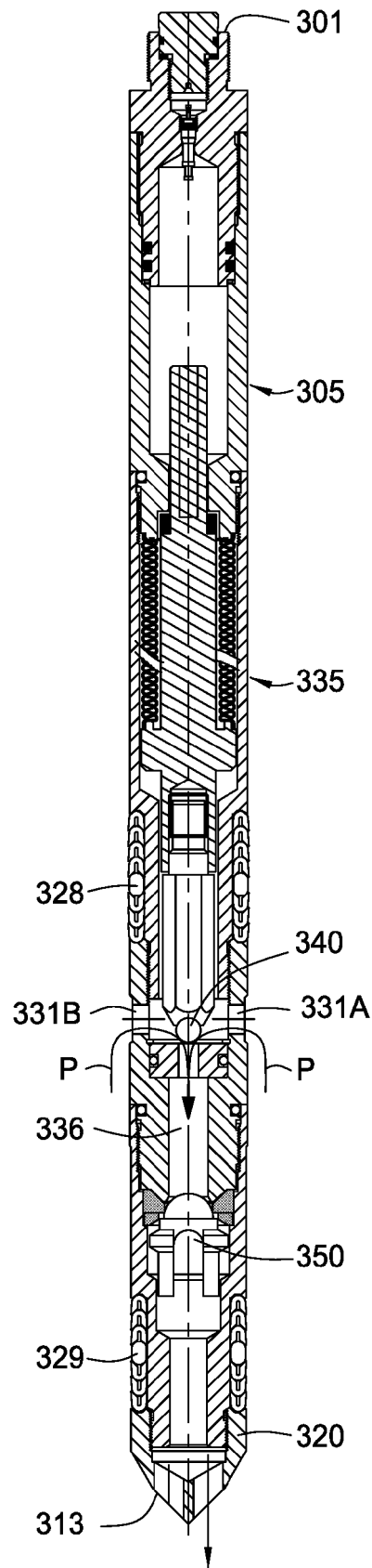


FIG. 3



EUROPEAN SEARCH REPORT

Application Number
EP 17 19 5984

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DOCUMENTS CONSIDERED TO BE RELEVANT			
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Y	US 2010/326661 A1 (KHOMYNETS ZINOVIIY DMITRIEVICH [RU]) 30 December 2010 (2010-12-30) * paragraph [0009]; figure 1 *	1-16	INV. E21B43/12 E21B34/06 E21B34/10 E21B23/03
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			TECHNICAL FIELDS SEARCHED (IPC)
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The present search report has been drawn up for all claims			
Place of search The Hague		Date of completion of the search 5 March 2018	Examiner Dantinne, Patrick
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

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EPO FORM 1503 03.02 (P04C01)

**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 17 19 5984

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This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
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