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(54) **WELL COMPLETION METHOD**

(57) The method pertains to the oil and gas industry and can be used in the development of producing formations. A producing string (6) together with a sealing device (7) are lowered into a well (1) and the well (1) is divided into an upper cavity (8) and a lower cavity (9) with the aid of said sealing device (7) to establish a hydraulic connection between the well opening and the upper cavity and between the lower cavity and the producing formation, respectively. The installation of equipment (10) and a check valve is carried out stepwise. A washer fluid (4) is replaced by a washer fluid (15). The equipment (10) is passed through the sealing device (7) and the hydraulic connection between the well opening, the lower cavity and the producing formation is re-established along the annular channel. The well (1) is deepened using the equipment (10) until an inflow of formation fluids occurs, the differential pressure in the hydraulic system "well opening - producing formation" being adjusted using the check valve and a blowout preventer (3). The equipment (10) is withdrawn from the lower cavity (9) upon completion of deepening, the device (7) is closed during separation of the cavity (9) from the cavity (8) and cutting-off the hydraulic connection between the producing formation and the upper cavity. The technical solution increases the efficiency and quality of technical operations and prevents the undesired inflow of formation fluids. 4 figures.

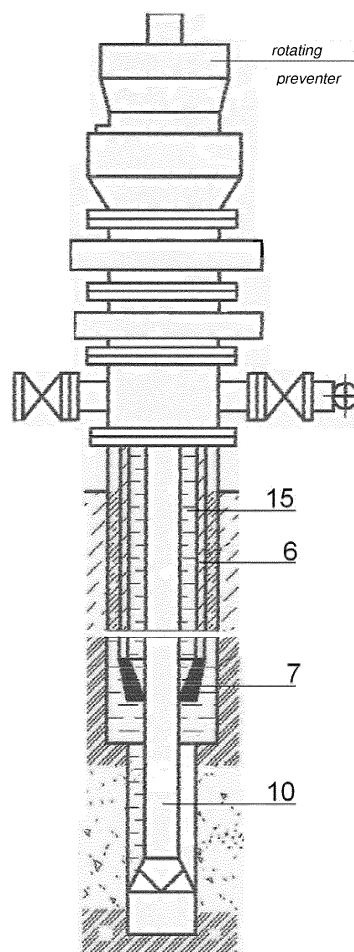


Fig. 3

Description

TECHNICAL FIELD

[0001] The invention pertains to the oil and gas industry, namely to drilling and operation of oil and gas wells, and can be used in the development of producing formations and well completion.

PRIOR ART

[0002] According to a known method of primary development of producing formations in the course of drilling for oil and gas, optimum conditions for primary development are produced with the use of different compositions of drill fluid, RU No. 2283418 C2, E21B21/00, 10.09.2006.

[0003] The known method relates to selection of reagents added to the drill fluid depending on the stage of operations performed on development of producing formations.

Another known method of well completion consists of primary development of the producing formation, fastening of producing strings and secondary development of the producing formation, RU No. 2140521 C1, E21B33/13, 27.10.1999.

[0004] The known method provides decrease in the overbalance on account of overlapping of high-pressure formations by producing string during its installation in the producing formation top.

[0005] Also known is a safety valve controlling downhole equipment and used during operation of oil and gas wells under pressure, RU No. 2311526 C2, E21B34/06, 27.11.2007; RU No. 2250354 C2, E21B34/06, 20.04.2005.

[0006] A special tool is used to control opening or closing of the known safety valves, which is a part of the drill or producing string depending on the type of work performed.

[0007] Also known are the technical conditions for development of producing formation in the presence of the constant hydrodynamic connection between the producing formation and the well opening, including well filling with washing liquid and creation of excess pressure (overbalance) on the producing formation by the washer fluid with the density increased relative to formation pressure gradient equivalent, "Unified technical rules of operations in construction of wells in oil, gas and gas-condensate fields", NPAOP 11.21.18 - 82.

[0008] Minimum permissible overbalance value must not be less than 3% of formation pressure value:

$$P_h > 1.03 P_{\text{form}},$$

where P_h - hydrostatic pressure of washer fluid column on the producing formation;

P_{form} - formation pressure.

When washer fluid is pumped, the overbalance on the bottomhole (accounting for the pressure loss in annulus and pressure of immersed jet coming from the bit nozzles) increases.

[0009] Also known is the method of completion of well equipped with producing string, downhole equipment (drill string), blowout preventer equipment, consisting in lowering the producing string to the producing formation top, installation of downhole equipment (drill string), well deepening to the budgeted depth with recirculation of washer fluid, prevention of formation fluid inflow, lifting of downhole equipment (drill string) and fixation of producing formation gross interval, A.I. Bulatov, P.P. Makarenko, V.F. Budnikov, Yu.M. Basarygin "Theory and practice of well completion". Rev. by A.I. Bulatov. - M.: OJSC "Publishing house "Nedra", 1998. T.4.

[0010] This technical solution is accepted as "closest analog" of the present invention.

[0011] In the "closest analog", during the development of producing formation the formation fluid inflows are prevented by creation of overbalance by the washer fluid column, which leads to absorption, increase in washer fluid flow rate, reduction of effective permeability of the producing formation and decrease in oil production.

[0012] The known method of development of the producing formation confirms the presence of constant hydraulic connection between the producing formation and well opening provided by the washer fluid which prevents undesired inflow of formation fluids to the well. This is achieved by creation of excess pressure on the producing formation by washer fluid. Excess of washer fluid pressure over the formation pressure leads to its inevitable overflowing to the producing formation. Intensity and volumes of absorption depend on collecting properties of the developed formations and make up from several cubic meters to tens and even hundreds cubic meters; besides, the washer fluid which came into producing formation significantly decreases effective permeability and, consequently, well productivity, which leads to decrease in oil production, and increase in the the cost and time of operations.

[0013] Thus, availability and value of overbalance on the producing formation has primary effect on the quality of the constructed well during the well completion. Development defects lead to deterioration of collecting properties of the producing formation - its blockage. This can be the result of high difference between the producing formation pressure and well hydraulic pressure, physical-chemical properties of the washer fluid and time of contact between the producing formation and the well opening.

SUMMARY OF THE INVENTION

[0014] The invention solves the problem of increasing the efficiency and quality with which technical operations

can be carried out and prevent the undesired inflow of formation fluids.

[0015] According to the invention this problem is solved by using the method of completion of a well equipped with producing string, downhole equipment (drill string), blowout preventer equipment, comprising the steps of lowering the producing string to the producing formation top, installation of downhole equipment (drill string), well deepening to the budgeted depth with recirculation of washer fluid, prevention of formation fluid inflow, lifting of downhole equipment (drill string) and fixation of producing formation gross interval.

[0016] The sealing device is lowered on the producing string, dividing the well into the upper and lower cavities with the hydraulic connection "well opening - upper cavity" and "lower cavity - producing formation", correspondingly, and is capable of rotation.

[0017] The return valve and the downhole equipment (drill string) is installed stage-by-stage to the sealing device.

[0018] The washer fluid is replaced with that creating hydrostatic pressure which is less than that in the formation.

[0019] The downhole equipment (drill string) is passed through the sealing device which is capable of separating during installation of downhole equipment (drill string) and re-establishment of hydraulic connection between the well opening, the upper cavity, the lower cavity and the producing formation along the annular channel.

[0020] The well is deepened using the downhole equipment (drill string) located in the lower cavity of the sealing device until an inflow of formation fluids occurs, the differential pressure in the hydraulic system "well opening - producing formation" being adjusted using the check valve and a blowout preventer.

[0021] The downhole equipment (drill string) is withdrawn from the lower cavity upon completion of deepening, the sealing device is closed during separation of the lower cavity from the upper cavity and cutting-off the hydraulic connection between the producing formation and the upper cavity.

[0022] The applicant has not identified any sources of information which contain data on technical solutions identical to the method applied for.

[0023] Thus, in the applicant's opinion, the invention satisfies the "novelty" (N) criterion.

[0024] The immediate technical result consists in implementation of hydraulic circulation of washer fluid before and after the producing formation development with the use of check valve and blowout preventer, by means of installation of sealing device and subdivision of the well into the upper and the lower cavities and establishment of hydraulic connection between the well opening and the upper cavity and between the lower cavity and the producing formation, by means of installation and passing of the downhole equipment (drill string) through the sealing device with re-establishment of the hydraulic connection between the well opening, the upper cavity,

the lower cavity and the producing formation, deepening of the producing formation until the formation fluids inflow occurs, with adjustment of the differential pressure in the hydraulic system "well opening - producing formation" using the check valve and a blowout preventer and with cutting-off of the hydraulic connection between the producing formation and the upper cavity after removal of downhole equipment (drill string) from the lower cavity and closing of the sealing device.

[0025] Implementation of distinguishing features of the invention determines a number of important technical effects:

When the washer fluid ceases to create overbalance on the producing formation due to installation of the sealing device in the producing formation top, which prevents undesired inflow of formation fluids, this decreases the washer fluid flow rate and increases the well productivity.

[0026] Subdivision of well by means of sealing device into the upper and the lower cavity provides creation of the hydraulic connections between the well opening and the upper cavity and between the lower cavity and the producing formation, correspondingly, thus cutting-off the direct hydraulic connection between the producing formation and the well opening and preventing undesired inflow of the formation fluids.

[0027] The sealing device, capable of separating, during the downhole equipment installation, and re-establishing the hydraulic connection between the well opening, the upper cavity, the lower cavity and the producing formation, limits the action time of the direct hydraulic connection between the producing formation and the well opening, thus reducing the action time of the formation fluids inflow.

[0028] Well deepening by means of the downhole equipment (drill string) until an inflow of formation fluids occurs, with adjustment of the differential pressure in the hydraulic system "well opening - producing formation" being adjusted using the check valve and a blowout preventer allows preventing the inflow of the formation fluids and increasing the efficiency of the well completion.

[0029] This technical result does not come from the known properties; at the same time, no publications are known to contain any information on influence of the invention's distinguishing features on the achieved technical result, which allows, in the applicant's opinion, claiming that the technical solution applied for meets the "inventive step" (IS) criterion.

[0030] Implementation of the technical solution applied for is confirmed by research, development and testing of experimental batches; to implement the method use is made of the equipment which is widely used in the oil and gas producing industry, which confirms, in the applicant's opinion, its meeting the "industrial applicability" (IA) criterion.

BRIEF DESCRIPTION OF THE DRAWINGS

[0031] Further on the technical solution applied for shall be explained by description of the example of its implementation with references to the attached drawings, where

- in Fig. 1 - Well, schematically;
- in Fig. 2 - Well with sealing device, schematically;
- in Fig. 3 - Well in operating position, schematically;
- in Fig. 4 - Sealing device, section.

PREFERRED EMBODIMENT OF THE INVENTION

[0032] In Fig. 1 - 4 represented:

- Well - 1.
- Opening - 2
- Blowout preventer - 3.
- Washer fluid - 4.
- Producing formation - 5.
- producing string - 6.
- Sealing device - 7.
- Upper cavity (well 1) - 8.
- Lower cavity (well 1) - 9.
- Downhole equipment (drill string) with check valve - 10.
- Housing (device 7) - 11.
- Thread (on housing 11) - 12.
- Bearing - 13.
- Sealing in the form of a collet - 14.
- Washer fluid - 15.

[0033] The well (1) with the opening (2) is equipped for operations on the primary development of the producing formation (5). The well (1) is filled with the washer fluid (4).

[0034] Blowout preventer (3) in the form of the universal and ram-type preventers (fig. 1) is installed on the opening (2) to prevent blowouts of formation fluids, and the manifold with the choke (fig. 1) for adjustment of the intensity of washer fluid flow from the well (1) during process operation on the well (1) deepening.

[0035] The rotating preventer (fig. 3) is installed on the opening (2) for sealing of the downhole equipment (drill string) (10) and the wall of the well (1) near the opening (2) during process operation on the well (1) deepening. The downhole equipment (drill string) (10) contains the check valve (not shown). The check valve is installed on the producing string (6) in the process of the downhole equipment (drill string) (10) lowering until its lower part reaches the sealing device (7) (until the downhole equipment (drill string) (10) is passed through the sealing device (7)).

[0036] Installed in the top of the producing formation (5) is the producing string (6) with the sealing device (7).

[0037] The sealing device (7) divides the well (1) into the upper (8) and the lower (9) cavities (fig. 2).

[0038] The sealing device (7) is made, for example, in the form of a collet capable of separating during the downhole equipment (drill string) (10) installation.

[0039] The sealing device (7) contains the housing (11), the bearing (13) and the seal assembly (14). The housing (11) is made with a thread (12) for connection with the producing string (6). The seal assembly in the form of a collet (14) is located in the housing (11) secured in the bearing (13) (fig. 4).

[0040] The sealing device (7) is capable of rotating, providing "closed" and "open" positions, passing the downhole equipment (drill string) (10) and overlapping the cross-section of the producing string (6).

[0041] The shown sealing device (7) is not limiting the invention applied for, as it is the example of implementation of the suggested method.

[0042] The sealing device can be made in the form of any known device meeting the requirements of reliable pressurization, capable of separating during interaction with the downhole equipment (drill string) in order to pass it and install in operation position.

[0043] The method is implemented as follows.

[0044] The well (1) is filled with the washer fluid (4).

The sealing device (7) is lowered into the top of the producing formation (5) on the producing string (6).

[0045] Lowering of the sealing device (7) is carried out in the open position, and after extrusion of cement grout and displacement of the cement plug downwards the sealing devices (7) takes up a position "closed".

The well (1) is divided by the sealing device (7) into the upper (8) and the lower (9) cavity.

[0046] The upper cavity (8) provides the hydraulic connection between the well opening and the upper cavity.

[0047] The lower cavity (9) provides the hydraulic connection between the lower cavity and the producing formation.

[0048] In that configuration, there is no direct hydraulic connection between the producing formation and the well opening.

The downhole equipment (drill string) (10) with the check valve is installed to the sealing device (7).

[0049] The downhole equipment (drill string) (10) is installed after the casing cementing and execution of preparatory operations.

[0050] The return valve and the downhole equipment (drill string) (10) is installed stage-by-stage to the sealing device (7).

The washer fluid (4) is replaced with the washer fluid (15) creating hydrostatic pressure which is less than that in the formation.

[0051] The washer fluid (4) is replaced with the washer fluid (15) the hydrostatic pressure of which summarized with the pressure loss in the annulus will meet the following requirement:

$$P_h + P_l < P_{\text{form}},$$

where P_h - hydrostatic pressure;

P_l - pressure loss in the annulus;

P_{form} - formation pressure.

The condition ensuring creation of the hydrostatic pressure less than the formation pressure with the help of the washer fluid (15) makes it possible to perform further process operations without overbalance.

[0052] Application of oil or petroleum products as a washer fluid (15) is most preferable; in that case, no wetting of the collectors with water filtrates takes place and, correspondingly, effective permeability is not decreased.

The downhole equipment (drill string) (10) is passed through the sealing device (7).

[0053] While passing the downhole equipment (drill string) (10) through the sealing device (7) it opens, and while pumping the washer fluid (15) to the downhole equipment (drill string) (10) along the annular channel the hydraulic connection between the well opening, the upper cavity, the lower cavity and the producing formation is re-established.

Deepening of the well (1) is performed until inflow signs occur with circulation of the washer fluid (15).

[0054] Prior to develop the producing formation (5) the rotating preventer (Fig. 3) is put into operation and the washer fluid (15) after being lifted to the opening (2) is directed to the manifold and to the circulation system through the adjustable choke (Fig. 1).

Further deepening of the well (1) is carried out.

The evidence of the producing formation (5) development beginning is the growing intensity of the flow coming to the opening (2). The intensity of the flow coming from the well is adjusted by means of the manifold choke (fig. 1).

Deepening of the well (1) is carried out with adjustment of the washer fluid outflow intensity.

[0055] The intensity of the washer fluid outflow is adjusted by the manifold choke (Fig. 1) of the blowout preventer (3).

Deepening of the well (1) is completed and circulation of washer fluid (15) is terminated.

[0056] After complete development of the producing formation (5), pumping of the washer fluid (15) is terminated; at that, the check valve is closed automatically and the hydraulic connection through the inner channel of pipes is cut off.

10 The downhole equipment (10) is lifted thus cutting off the hydraulic connection between the producing formation and the upper cavity.

[0057] After removal of the downhole equipment (drill string) (10) from the lower cavity (9) of the well (1) the sealing device (7) is closed and the hydraulic connection between the producing formation and the upper cavity is terminated; at that, the lower cavity (9) is sealed from the upper one being under constant formation pressure (P_{form}); at that, the formation fluids inflow from the lower cavity into the upper cavity becomes impossible.

[0058] Further actions are determined by the correlation:

$$P_{\text{form}} - P_h < P_{\text{ws}},$$

where P_{form} - formation pressure;

P_h - hydrostatic pressure;

P_{ws} - working pressure of the sealing device.

If requirements of this correlation are met, further lifting of the downhole equipment (drill string) (10) is possible.

35 **[0059]** If the difference between the formation (P_{form}) and hydrostatic (P_h) pressure of the washer fluid (15) in the upper cavity (8) is greater than the working pressure (P_{ws}) of the sealing device (7), then the washer fluid (15) is replaced with the other fluid the density of which allows meeting the requirements of the described correlation, after that further lifting of the downhole equipment (drill string) (10) can be performed.

45 Fixation of the producing formation (5) interval is carried out.

[0060] In order to fix the interval of the producing formation (5) bedding the tail pipe (not shown) is lowered similar to lowering of the downhole equipment (drill string) (10); at that, the tail pipe can overlap the lower cavity (9) only, and the sealing device (7) in this case will serve as a safety valve.

[0061] The suggested method can open any formation fluids, including: oil, gas, water or combinations thereof.

[0062] The suggested method can be implemented in the wells with any inclination angle.

[0063] The suggested method allows:

- increasing in efficiency and quality of process operations during the well completion;
- preventing the undesired inflow of formation fluids without creation of overbalance by the washer fluid on the producing formation; 5
- increasing the well productivity;
- reducing the action time of the direct hydraulic connection between the producing formation and the well opening. 10

INDUSTRIAL APPLICABILITY

[0064] In the suggested method the use is made of the equipment which is widely used in the oil and gas producing industry, which results, in the applicant's opinion, in its meeting the "industrial applicability" (IA) criterion. 15

Claims

1. The method of completion of a well equipped with the producing string, downhole equipment (drill string), blowout preventer, comprising lowering the producing string into the producing formation top, installation of the downhole equipment (drill string), deepening of the well to the budgeted depth with circulation of the washer fluid, prevention of fluids inflow formation, lifting of downhole equipment (drill string) and fixation of producing formation bedding interval, differing in that the sealing device is lowered on the producing string, which divides the well into the upper and the lower cavities with the hydraulic connection between the well opening and the upper cavity and between the lower cavity and the producing formation, respectively, capable of rotation; the check valve and the downhole equipment (drill string) are installed step-by-step down to the sealing device, the washer fluid is replaced with the washer fluid creating the hydrostatic pressure less than the formation pressure, the downhole equipment (drill string) is passed through the sealing device which is capable of separating during the downhole equipment (drill string) installation and re-establishment of the hydraulic connection between the well opening, the upper cavity, the lower cavity and the producing formation along the annular channel, the well is deepened with the help of the downhole equipment (drill string) located in the lower cavity of the sealing device until the formation fluids inflow occurs, with adjustment of the differential pressure in the hydraulic system "well opening - producing formation" by means of the check valve and the blowout preventer, the downhole equipment (drill string) is removed upon completion of deepening from the lower cavity with closing of the sealing device and separation of the lower cavity from the upper cavity and cutting off the hydraulic connection between the producing formation and the upper cavity. 20 25 30 35 40 45 50 55

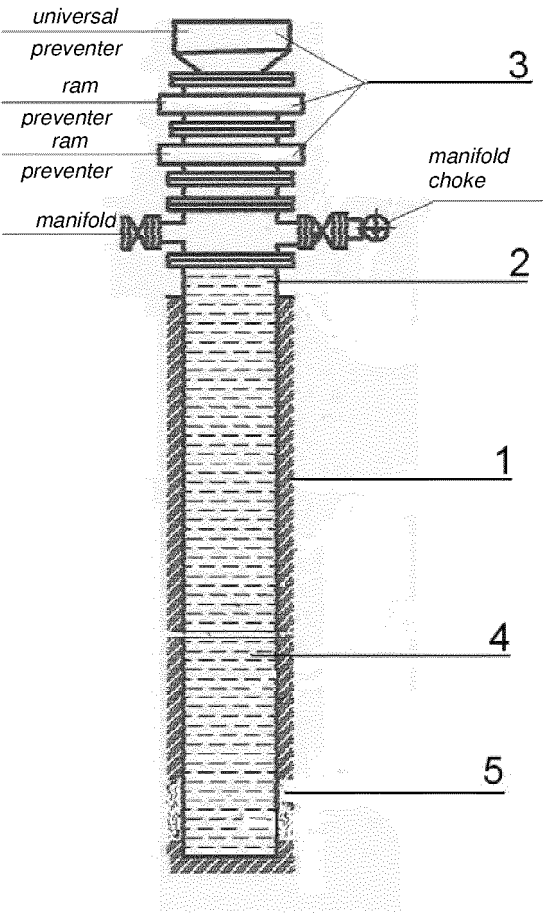


Fig. 1

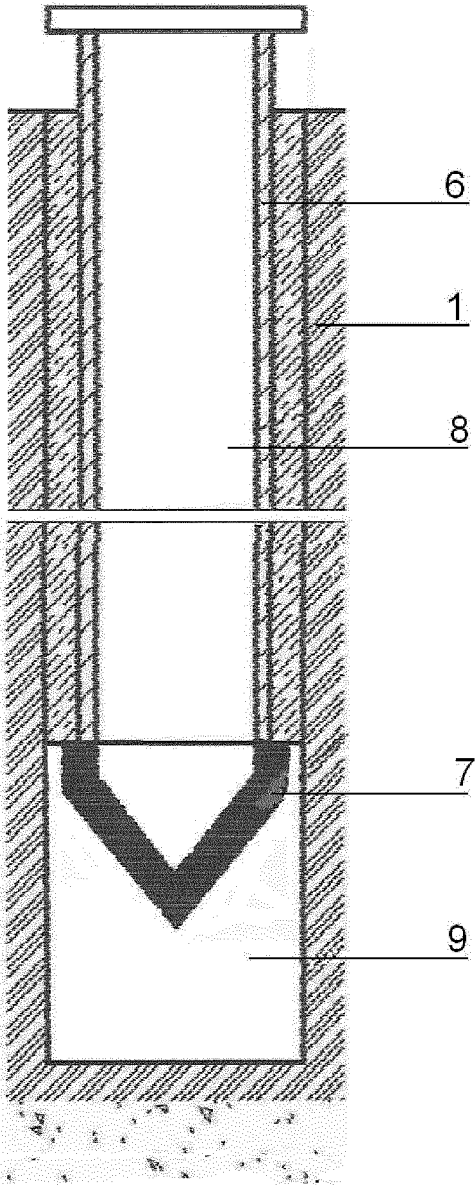


Fig. 2

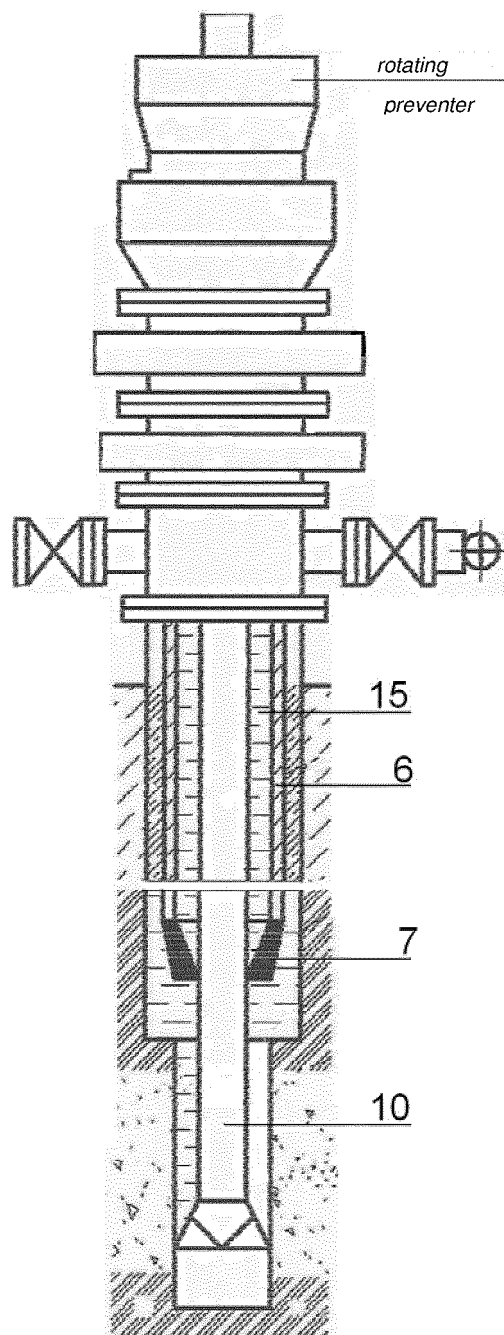


Fig. 3

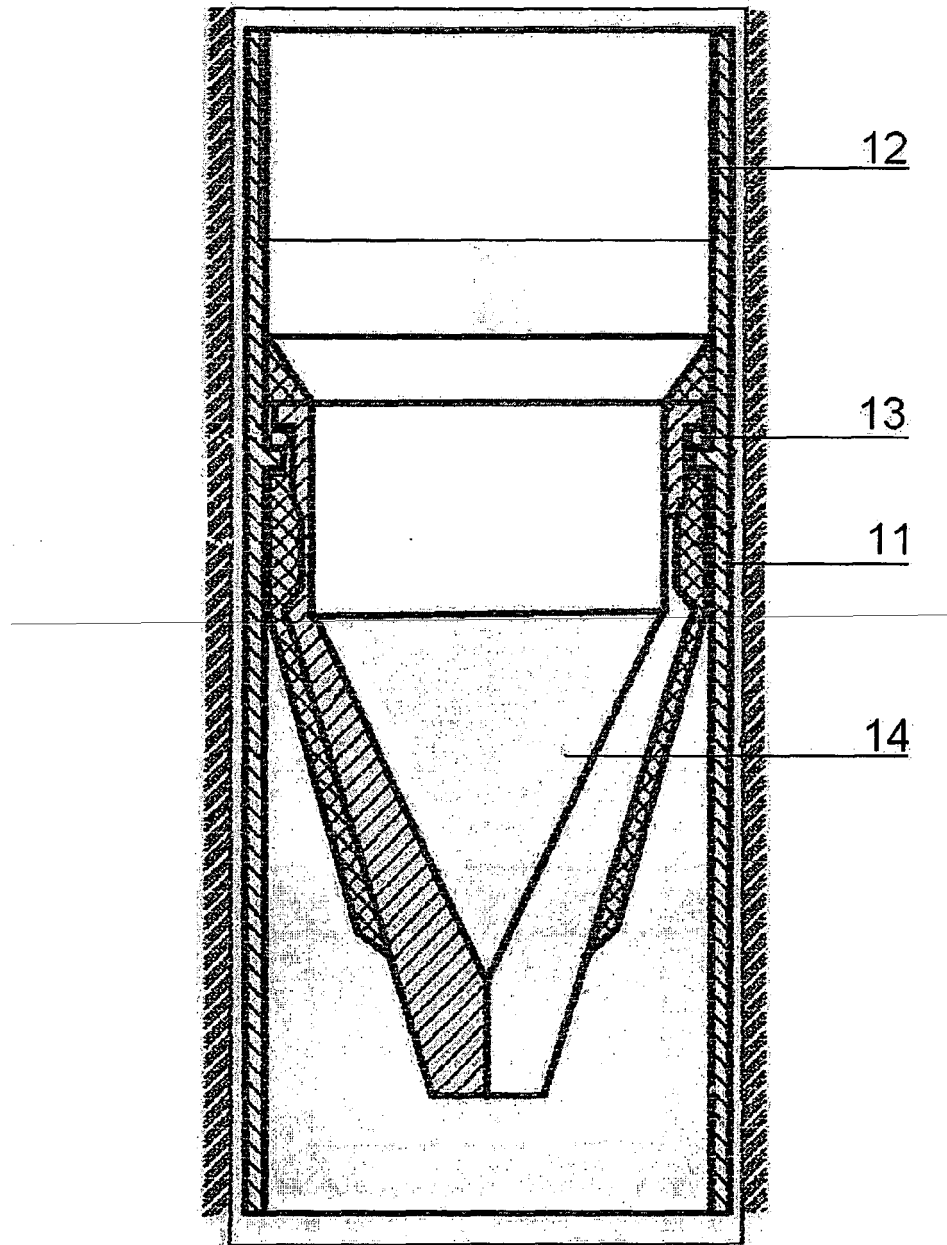


Fig. 4

INTERNATIONAL SEARCH REPORT

International application No.
PCT/RU 2010/000293

A. CLASSIFICATION OF SUBJECT MATTER		E21B 43/00 (2006.01) E21B 7/00 (2006.01)
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)		
E21B 7/00, 21/00, 21/08, 21/10, 34/00, 34/06, 43/00		
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)		
EAPATIS, Esp@cenet, RUPTO, PatSearch		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	RU 2250354 C2 (OTKRYTOE AKTSIONERNOE OBSHESTVO "NAUCHNO-PROIZVODSTVENNOE OBEDINENIE "BURENIE" et al.) 20.04.2005	1
A	SU 1661356 A1 (VOLGOGRADSKY GOSUDARTVENNY NAUCHNO-ISSLEDOVATELSKY I PROEKTNY INSTITUT NEFTYANOY PROMYSHLENNOSTI) 07.07.1991	1
A	SU 1816030 A1 (VSESOYUZNY NAUCHNO-ISSLEDOVATELSKY I PROEKTNO-KONSTRUKTORSKY INSTITUT PO VZRYVNYM METODAM GEOFIZICHESKOY RAZVEDKI) 20.07.1996	1
A	US 2009/0065257 A1 (JOE NOSKE et al.) 12.03.2009	1
☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.		
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Date of the actual completion of the international search	Date of mailing of the international search report	
13 September 2010 (13.09.2010)	30 September 2010 (30.09.2010)	
Name and mailing address of the ISA/	Authorized officer	
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REFERENCES CITED IN THE DESCRIPTION

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