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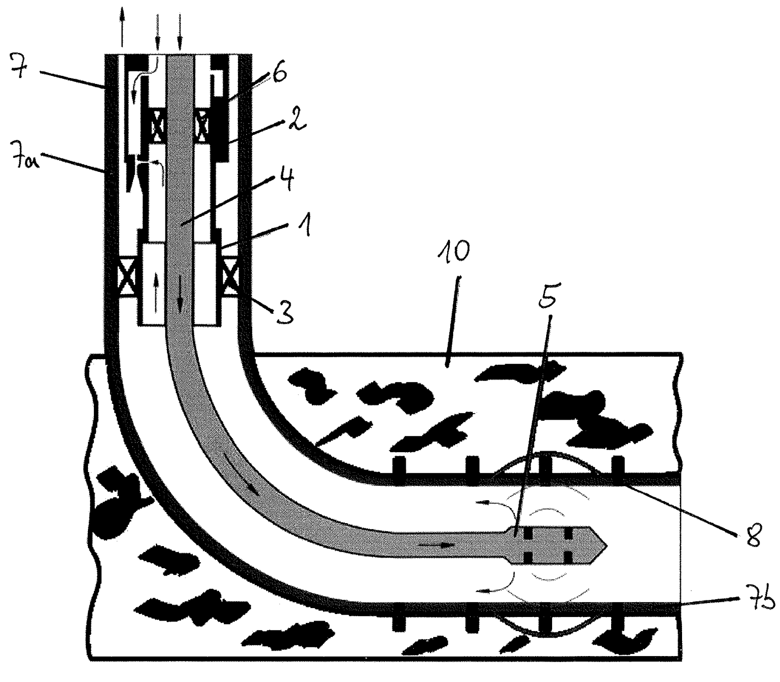
(54) **METHOD FOR RECOVERY OF OIL AND/OR GAS**

(57) Method for the recovery of oil and/or gas from a reservoir (10) by operating in a well (7) a pump (2) and a hydraulic pressure impulse generator (5), wherein the method further comprises the step of determining, in a preliminary study in a test unit, a fluid pulse amplitude and a fluid pulse frequency of the hydraulic pressure impulse generator (5), and a total pressure (Pt) to be established in the well (7).

Fig. 1

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## Description

**[0001]** The present invention refers to a method for the recovery of oil and/or gas from a reservoir (hydrocarbon reservoir). The invention relates in particular to mining operations, where deposits are developed by a downhole method, and can be used in oil and/or gas industry for oil and/or gas wells development and intensification, as well as during shale and coal gas production.

**[0002]** It is known in the art that an enhancement of oil and/or gas recovery from a reservoir can be achieved by creating a grid of fatigue rock cracks by a series of sign-variable pressures. The produced grid fracturing in the rock leads to an increased permeability of the reservoir bottom-hole zone (RBZ).

**[0003]** It is further known in the art to create the fatigue fracturing grid by using a hydraulic pressure impulse generator. However, it is a disadvantage of this method that there cannot be created conditions for an efficient removal of colmatant particles from the reservoir bottom-hole zone through the created cracks.

**[0004]** It is in an object from the present invention to provide an optimized method for the recovery of oil and/or gas from a reservoir, in particular a method for enhancing oil and/or gas reservoir recovery.

**[0005]** The object is solved according to the invention by a method according to claim 1. Preferred embodiments of the invention are defined in the dependent claims. The invention is further described in the appended description, in particular taken together with the attached drawing.

**[0006]** According to the invention, there is provided a method for the recovery of oil and/or gas from a reservoir by operating in a well a pump and a hydraulic pressure impulse generator, wherein the method further comprises the step of determining, in a preliminary study in a test unit, a fluid pulse amplitude and a fluid pulse frequency of the hydraulic pressure impulse generator and a total pressure to be established in the well.

**[0007]** The invention provides a specific process flow in the well in order to create a grid of fatigue rock cracks during the action on the rock by a series of sign-variable pressures. This is done with periodic pulse trains from a hydraulic generator and the simultaneous producing of the necessary drawdown pressure using a pump, in particular an ejector pump, or jet pump. The simultaneous generation of the necessary drawdown pressure enhances the oil and/or gas recovery from the reservoir. With the inventive method, the permeability of the reservoir bottom-hole zone (RBZ) can quickly and environmentally friendly be increased by fatigue grid fracturing in the reservoir bottom-hole zone, while generating the necessary drawdown pressure using the pump.

**[0008]** The reservoir drawdown pressure leads to the occurrence of additional stresses in the reservoir, which in conjunction with a simultaneous impact of reservoir fluid pulse pressure allow to significantly accelerate the process of fatigue fracturing, as compared to the fluid pulse pressure exposure only without reservoir drawdown pressure. The drawdown pressure effects help sufficiently clean the reservoir bottom-hole zone from colmatation during fluid pulses and drawdown pressure.

**[0009]** That is, a first basic idea of the invention is the generation of periodic pulses or periodic pulse trains by a hydraulic generator and the simultaneous operation of a pump for reducing the pressure in the well, thereby producing the necessary drawdown pressure. In other words, the reservoir pressure pulse processing is carried out simultaneously with the creation of (a regulated) reservoir drawdown pressure, using the pump. Thereby, an efficient removal of colmatant particles from the reservoir bottom-hole zone can be achieved together with the creation of additional cracks in the reservoir so as to increase the permeability of the reservoir. The pump is preferably an ejector pump (or jet pump).

**[0010]** A second basic idea of the invention is the conduction of a preliminary study in a test unit with a view to determining operating parameters of the hydraulic pressure impulse generator (i.e. its pulse amplitude and pulse frequency) and the total pressure to be established in the well. In particular, the preliminary study is carried out for experimentally determining optimal values of the total pressure in the well and of the fluid pulse amplitude and fluid pulse frequency of the impulse generator. Optimal parameters are in particular such parameters where the permeability of the reservoir reaches a high, preferably a maximum value.

**[0011]** The inventive method can be used in particular for the intensification of oil and/or gas recovery from the so-called "traditional" permeable reservoirs, such as for example sandstone or limestone, by increasing the permeability of the layer zones in case of contamination (clogging). The permeability of a reservoir bottom-hole zone may be increased by the creation of microfractures. These microfractures will accelerate, under the effect of a drawdown pressure, the movement of clogging substances, such as microparticles of clay and/or rock, paraffin solutions, resins, asphaltenes, mud particles, etc. towards the well. In addition, the inventive technology can be used to stimulate the production of oil and/or gas from tight or impermeable rocks of shale and/or coal beds, as well as the intensification of layer fracturing (fracking) by creating a network of micro-cracks, which lead, as a result, to the increase of inner surface. This ultimately leads to the intensification of the process, i.e. the transition of the oil and/or gas molecules from the rock formation to the fracture area.

**[0012]** The total pressure in the well (sum-pressure) is the sum of a mean pressure of the fluid pulses generated by the hydraulic pressure impulse generator and of the pressure generated by the pump working in the well. The pump placed in the well reduces the pressure in the well, in particular in a packer zone. At the same time the hydraulic pressure impulse generator increases the pressure by means of a constant component of the fluid pulse pressure (fluid pressure pulses). This constant component in turn depends on the fluid pulse amplitude and the fluid pulse frequency (duty cycle).

**[0013]** Thus, the total pressure in the well depends on the suction pressure of the pump placed in the well and on the fluid pulse amplitude and fluid pulse frequency of the hydraulic pressure impulse generator. The preliminary study in the test unit (not in the well) permits determining experimentally the amplitude and the frequency of the pulses, and thus compute its effective mean pressure value, as well as the needed total pressure (sum-pressure) in the well. It is, therefore, an advantage of the present invention that these parameters can be determined beforehand, i.e. before actually operating the pump and the hydraulic pressure impulse generator in the well.

**[0014]** In a preferred embodiment of the invention, in the preliminary study, in order to obtain values for the fluid pulse amplitude and the fluid pulse frequency of the hydraulic pressure impulse generator and the total pressure in the well, a fluid pulse amplitude, a fluid pulse frequency and a pressure (or pressure profile) in a test unit, in which a sample is placed, are sequentially changed to values at which the sample reaches a maximum permeability. Thus, the values are determined experimentally in a test unit. Preferably, the test unit comprises a test chamber (study chamber), in which the sample, preferably a rock sample, is placed. The sample can be a sample, for example a core, taken from the reservoir. The sample is placed in the test chamber of the test unit. The test chamber is preferably a pressure chamber. The sample is preferably pressurized. By varying the values of the fluid pulse amplitude, fluid pulse frequency and pressure (or pressure profile) in the test unit (in the pressure chamber), values or ranges of values for the fluid pulse amplitude and frequency and total pressure in the well can be determined. In another preferred embodiment of the invention, in the preliminary study, a sample representative of the reservoir is exposed in the test unit to fluid pressure pulses (a fluid pulse pressure). The fluid pressure pulses are created by a hydraulic pressure impulse generator of the test unit, which can also be referred to as a test hydraulic pressure impulse generator. The test hydraulic pressure impulse generator can be of the same type or a different type as the hydraulic pressure impulse generator used within the well. A hydraulic pressure impulse generator is well known in the art and operated by a continuous flow of a working fluid to the generator. A valve of the hydraulic pressure impulse generator is operated at a given frequency to generate a pulsed flow of the working fluid, thereby generating fluid pulses on the fluid in the well. Reference is made for example to UA 63412 A and UA 100920 C2 which are incorporated herein by reference, in particular regarding the hydraulic pressure impulse generators described therein.

**[0015]** In another preferred embodiment of the invention, in the preliminary study, conditions relative to pressure and/or temperature are established in the test unit, which are (is) representative of the reservoir. In other words, preferably, thermobaric conditions relevant to (representative of) the reservoir conditions are created in the test unit, in particular in the test chamber of the test unit. The reservoir, as referred herein, preferably in means an area surrounding the well, in particular the part of the well where the hydraulic pressure impulse generator is placed. The chamber of the test unit is pressurized to a pressure value according to the reservoir conditions.

**[0016]** In still another preferred embodiment of the invention, in the preliminary study, a fluid pulse amplitude and a fluid pulse frequency of a hydraulic pressure impulse generator of a test unit (test hydraulic pressure impulse generator) are sequentially changed. The change of these parameters aims at finding optimal parameters, where the permeability of the sample reaches a high, preferably a maximum value. The permeability of the sample is determined by standard methods as known in the art. For determining the conditions in which a maximum permeability of the sample in the test unit is reached, a rock fatigue fracturing is created in the test unit.

**[0017]** It is furthermore preferred that in the preliminary study, a pressure drop over a sample is sequentially changed. This can be achieved by controlling a fluid flow via the sample. The sample can be exposed to a flow of fluid routed through the sample. By controlling the inlet flow and/or the outlet flow, the pressure drop in the sample can be changed. Alternatively it is possible that a suction pressure of a pump of the test unit (test pump) is sequentially changed. In other words, a pressure at the inlet of a pump (test pump) is changed or varied. The change of the pressure drop and/or the change of the suction pressure, or inlet pressure of the pump, aims at finding an optimal pressure, i.e. a value of a pressure where the permeability of the sample reaches a high, in particular maximum value.

**[0018]** In still another preferred embodiment of the invention, the total pressure to be established in the well is calculated as a sum of a mean pressure generated by a hydraulic pressure impulse generator of the test unit (test hydraulic pressure impulse generator) and a pressure drop in (across) the sample. In other words, during the preliminary study the total pressure is a sum of two pressures: mean pressure from the pulse (impulse) generator and pressure drop in (across) the tested sample. The simultaneous operation of the pump (preferably ejector pump) and the impulse generator (downhole generator) generates a certain amount (value) of the total pressure, and thus the drawdown pressure. To find the optimal value of this pressure, the pressure at the inlet nozzle of the ejector pump and preferably at the inlet of the hydraulic pressure impulse generator are changed (varied). The change of the pressure at the inlet of the hydraulic pressure impulse generator changes its amplitude (and/or its frequency).

**[0019]** According to the invention, the optimal value of the specified pressure is not determined numerically. The test unit creates thermobaric conditions that correspond to the reservoir conditions of a particular oil and/ or gas field. A stress-strain state of the formation (in particular rock formation) is simulated by the simultaneous operation of a pump (test pump) and a hydraulic pressure impulse generator in the test unit. In other words, the conditions in the well are modelled/simulated in a test unit on a sample which is preferably a reservoir rock sample (core), which has been taken preferably from the actual reservoir.

**[0020]** In the high-pressure chamber of the test unit, special conditions are created:

- a pressure difference across the sample (rock sample, core); this pressure difference is representative of the difference between reservoir pressure and well pressure, i.e. the drawdown pressure;
- a homogeneous compression of the sample; this pressure is representative of the reservoir pressure ;
- an alternating stress of the sample, using a (special) pulse (impulse) generator. This simulates the operation of the hydraulic pressure impulse generator in the well.

**[0021]** The test unit or test device for testing the permeability of a sample (core sample, sample core) under pressure pulses preferably comprises a high pressure chamber, a core sample holder, a hydraulic pressure impulse generator (hydraulic generator, test hydraulic pressure impulse generator), a heating unit, and a pump supplying fluid to the hydraulic generator. In addition, the test unit preferably comprises a fluid inlet and a fluid outlet of the high pressure chamber. In the high pressure chamber, fluid is routed from the fluid inlet to the fluid outlet (only) via (through) the sample. The pressure drop in the sample is varied. In addition, the fluid pulse amplitude and a fluid pulse frequency of the test hydraulic pressure impulse generator are varied. The pressure drop and the fluid pulse amplitude and frequency are varied so as to find optimal values, i.e. values where the sample reaches a predetermined or maximum permeability.

**[0022]** The laboratory trials (tests) aim at investigating the permeability of the sample (core). By varying the pressure drop across the rock sample as well as the mean component of the generator pulses pressures (by changing the pulse amplitude and pulse frequency) a maximum possible (for the given conditions) permeability (amount of fracturing) of the sample can be determined/achieved.

**[0023]** For the determination of the permeability of the sample in the preliminary study, layer water extracted from the investigated oil or gas field (of reservoir) can be used. It is also possible to add additives, such as surfactants.

**[0024]** A drawdown pressure to be established during the extraction of oil and/or gas from the reservoir is preferably calculated by $\Delta P = (P_r - Pt)$, in which $P_r$ is a reservoir pressure and Pt is a total pressure in the well as determined in the preliminary study. The drawdown pressure $\Delta P$ is the difference between the reservoir pressure $P_r$ and the pressure Pt in the borehole at the depth of the reservoir. Therefore, the drawdown pressure $\Delta P$ can be calculated from the total pressure Pt in the well, as determined in the test unit by maximizing the permeability of the sample. As explained above, the total pressure Pt in the well is the sum of a mean pressure generated by the hydraulic pressure impulse generator and the suction pressure of the pump, in particular ejector pump. In other words, the calculation of the reservoir drawdown pressure $\Delta P$ is carried out according to the equation $\Delta P = P_r - P_e - P_c$, where $P_r$ is the reservoir pressure, $P_e$ is the pressure component of the total pressure in the well generated by the running ejector pump and $P_c$ is the constant (mean) pressure component of the total pressure in the well generated by the running hydraulic pressure impulse generator (hydrogenerator).

**[0025]** It is preferred that, during the extraction of oil and/or gas from the reservoir, a drawdown pressure $\Delta P$ calculated by $\Delta P = (P_r - Pt)$, in which $P_r$ is a reservoir pressure and Pt is the total pressure in the well, is maintained within predetermined limits, and more preferably kept constant (over time).

**[0026]** In another preferred embodiment of the invention, during the extraction of oil and/or gas from the reservoir, the fluid pulse amplitude and/or the fluid pulse frequency of the hydraulic pressure impulse generator are changed during the operation of the pump and the hydraulic pressure impulse generator in the well, i.e. while the pump and the hydraulic pressure impulse generator are running in the well (synchronous operation of pump and hydraulic pressure impulse generator).

**[0027]** In another preferred embodiment of the invention, during the extraction of oil and/or gas from the reservoir, a drawdown pressure $\Delta P$ calculated by $\Delta P = (P_r - Pt)$, in which $P_r$ is a reservoir pressure and Pt is the total pressure in the well, is maintained within predetermined limits, more preferably kept constant, by changing at least the fluid pulse amplitude and/or the fluid pulse frequency of the hydraulic pressure impulse generator.

**[0028]** In still another preferred embodiment of the invention, during the extraction of oil and/or gas from the reservoir, a drawdown pressure $\Delta P$ calculated by $\Delta P = (P_r - Pt)$, in which $P_r$ is a reservoir pressure and Pt is the total pressure in the well, is maintained within predetermined limits, more preferably kept constant, by changing at least a suction pressure of the pump.

**[0029]** As the drawdown pressure and the total pressure in the well are linked by the reservoir pressure, it can also be said that the total pressure in the well is maintained within predetermined limits, more preferably kept constant, in particular by changing at least the fluid pulse amplitude and/or the fluid pulse frequency of the impulse generator and/or by changing at least a suction pressure of the pump. This ensures an active or progressing creation of fatigue cracks in the reservoir. The total pressure is kept constant and equal to the pressure determined at the preliminary study of the sample.

**[0030]** I.e. a feature of the invention can be seen in the fact that the total pressure in the well and/or the drawdown pressure is kept constant during the synchronous functioning of the pump (ejector pump) and the hydraulic pressure impulse generator. During the concurrent or synchronized operation of the pump (ejector pump) and the impulse generator, the fluid pulse amplitude and/or the fluid pulse frequency (duty cycle) are varied so as to maintain the total pressure in the well and, accordingly, the drawdown pressure, so as to meet the criteria of fatigue cracks occurrence in the reservoir (formation, rock), thus permanently increasing its permeability. The value of the drawdown pressure, or pressure differential, $\Delta P$ is determined experimentally according to the study, as described herein. The change of the fluid pulse frequency and amplitude can be done manually and/or automatically.

**[0031]** It is worthwhile noting that the opening of an oil-bearing layer with a well changes the stress-strain state of the reservoir (formation, rocks) in the near-wellbore area as compared with the stress-strain state before opening the reservoir. By varying the pressure in the well, and thus the amount of drawdown pressure, the stress-strain state of the rock formation is changed, which, during the action of signalternating stresses due to the impulse generator, leads to the creation of cracks which in turn leads to the increased permeability of the formation. Thus, it is an essential feature of the invention that local permeability is increased by acting on the rock with sign-variable pressures to form additional grid rock cracks, wherein a periodic pulse pressure (or periodic pressure pulses) is (are) generated in the liquid medium of the well. The sign-variable pressures generated in the formation (rocks) cause elastic vibrations in the formation (rocks).

**[0032]** In an actual well, the presence of the drawdown pressure $\Delta P$ in the rock that before reservoir penetration was in a hydrostatic compression, i.e. the pressure differential between the reservoir pressure and the pressure in the well, creates radial tensile forces directed toward the well. Sign-variable pressures, occurring in the formation (rock) during the operation of the impulse generator under conditions promoting the occurrence of tensile forces, lead to the so-called rock asymmetric loading cycles, when fatigue cracks tend to occur more actively. Particular loading conditions of the rock ($\Delta P = P_r - Pt$) are specified in the test unit and then used in the real well.

**[0033]** The sum-pressure in the well during the synchronous functioning of the pump and the impulse generator determines the stress-strain state of the reservoir bottom-hole zone, and thus the fatigue strength of the (rock) reservoir. The required total pressure determined during the preliminary study is preferably kept constant by changing the flow rate and/or the pressure at the inlet of the ejector pump and/or the hydraulic pressure impulse generator.

**[0034]** The total pressure in the well, when the pump and the hydraulic pressure generator are operated, is preferably maintained within limits that have been determined before during the preliminary study (laboratory test) of the rock samples. In the packer space, depth gauge is set. If necessary, the pressure at the inlet of the ejector pump as well as the pressure and flow rate at the inlet of the hydraulic pressure impulse generator are changed to maintain the total pressure within predetermined limits.

**[0035]** As the pump operates continuously, with the increasing number of cracks and increasing rock permeability, the volume of fluid recovered from the reservoir will increase, too. Thus, at the same time, the fluid pulse amplitude and duty cycle (pulse frequency) should be regularly adjusted to maintain a constant value $\Delta P$.

**[0036]** A basic aspect of the invention is the change of the fluid pulse amplitude and the fluid pulse frequency of the hydraulic pressure impulse generator, as well as preferably also a suction pressure of the pump in the well, based on results from a preliminary study carried out in a test unit with the use of a sample taken from the reservoir, wherein the preliminary study determines values of fluid pulse amplitude and frequency, as well as preferably also a suction pressure of the pump, where permeability of the sample reaches a maximum value.

**[0037]** In particular, the following steps can be carried out according to the invention:

1. A preliminary study of reservoir rock samples is conducted in a laboratory (in a test unit). The preliminary study involves the determination of a required pressure in the well during a common operation of a hydraulic pressure impulse generator and a pump, in particular, an ejector or jet pump. For this purpose, thermobaric conditions relative to the reservoir conditions of a specific field are created in the test unit, and then the rock sample (or samples) is exposed to fluid pulse pressure. The fluid pulse amplitude and fluid pulse frequency, as well as the pressure in a chamber of the test unit are sequentially changed to values at which the permeability of the sample reaches a maximum value.

2. A pump, in particular an ejector pump, and a hydraulic impulse pressure generator are placed in a well.

3. The reservoir draw-down pressure $\Delta P$ is calculated according to the expression: $\Delta P = (P_r - P_t)$, where $P_r$ is a reservoir pressure, Pt is a value of the total pressure on the well bottom hole while the pump and the hydraulic pressure impulse generator are operated. The total pressure Pt is determined according to the preliminary study.

4. A working fluid is injected into a tubing string, thereby creating a pressure decrease in the well, using the ejector pump. The pressure is particularly decreased to a value that depends on strength characteristics of a casing (of the well) and/or a cement

stone.

5. The working fluid is also injected into the hydraulic pressure impulse generator, thereby producing a sequence of specified fluid pressure pulses with a certain constant pressure component. The value of the total pressure Pt in the well is determined by the preliminary study and is adjusted during the treatment of the reservoir by changing the fluid pulse amplitude and frequency.

**[0038]** The simultaneous pumping of working fluid into the tubing string and the flexible tubing has the effect that a maximum influx of reservoir fluid is reached.

**[0039]** The invention will now be further described with reference to the attached drawings, in which

Fig. 1 is a schematic drawing of a device (equipment) for the recovery of oil and/or gas from a reservoir and

Fig. 2 is a schematic drawing of a test unit according to the invention.

**[0040]** Fig. 1 shows in particular an equipment for a reservoir stimulation, i.e., for enhancing oil and/or gas recovery from a reservoir. For the recovery of hydrocarbons from the reservoir, an ejector pump 2 and a packer 3 are run into a well 7 on a tubing pipe 1 (tubing, tubing string). The well 7 includes perforations 8. In the shown embodiment, the well 7 includes a vertical portion 7a and a substantially horizontal portion 7b. The perforations 8 are arranged at the horizontal portion 7b of the well 7. The perforations 8 are arranged at a lower portion of the well 7.

**[0041]** The packer 3 is placed within the well 7, preferably at a distance of at least 5 meters, in particular, at least 10 meters above the perforations 8 (in particular, upper perforations at the horizontal portion 7b). A flexible tube 4 having at its distal end a hydraulic pressure impulse generator 5 is passed through a passage hole of the ejector pump 2 by means of a coiled tubing facility. A sealing 6 is introduced together with the flexible tube 4 for sealing a downward fluid path to the ejector pump 2 against a fluid path of extracted fluid from the well.

**[0042]** The hydraulic pressure impulse generator 5 is installed in an area of the well 7 having the perforations 8. After treatment of the reservoir at a first position, the hydraulic pressure impulse generator 5 is sequentially set in following positions in the zone of perforations, preferably with a pitch that is equal to the length of a radiating part of the hydraulic pressure impulse generator 5. Working fluid is injected into the tubing pipe or tubing string 1, thereby creating a pressure decrease in the area of the packer 3, using the ejector pump 2. The pressure is decreased to a value that depends on the strength characteristic of the casing (well) and/or the cement stone, and is determined by standard methods. Additionally, a working fluid is injected into the flexible tube 4 towards the hydraulic pressure impulse generator 5, thereby producing a sequence of specific fluid pressure pulses. The fluid pressure pulses have a constant pressure component. The value of the total pressure in the well is determined by the preliminary study according to the invention. The fluid pulse amplitude and fluid pulse frequency of the hydraulic pressure impulse generator 5 are changed during the treatment of the reservoir. This is done, in particular, by changing the flow rate and/or the pressure of the fluid in the flexible tube 4, in particular at the inlet of the hydraulic pressure impulse generator 5.

**[0043]** The ejector pump 2 without the impulse generator 5 will reduce the pressure in the well below the packer 3. For example, an ejector pump 2 of the type YЭOC-5M can be used, which is able to lower the pressure in the wellbore at a depth of 3000 m to 0.1 MPa. I.e. the ejector pump 2 almost completely relieves the hydrostatic head pressure in the wellbore. The pressure in the wellbore during running the ejector pump 2 depends on the pressure at the inlet of the pump nozzle. The impulse generator 5 itself with an idle ejector pump would increase the pressure in the wellbore.

**[0044]** Fig. 2 shows a test unit or test device 20 for testing the permeability of a sample 30 or sample core under pressure pulses.

**[0045]** The modeling of the stress-strain state of the sample 30 during the functioning of the ejector pump 2 and of the impulse generator 5 can be performed on a testing device or test unit 20 that will be described in the following:

The test unit 20 comprises a high pressure chamber 21 which is adapted to establish pressures according to a hydrocarbon reservoir. In the pressure chamber 21, there is arranged a core sample holder 22 for holding a core sample 30 to be tested. A hydraulic generator 23 (test hydraulic pressure impulse generator) is placed in the pressure chamber 21. A heating unit 24 is provided for heating the pressure chamber 21 to a temperature according to a hydrocarbon reservoir. The hydraulic generator 23 is connected to a pump 25 which supplies a hydraulic fluid to the hydraulic generator 23 for operating the hydraulic generator 23.

**[0046]** An inlet conduit 32 is connected to an inlet side of the high pressure chamber 21 and an outlet conduit 34 is connected to an outlet side of the high pressure chamber 21.

**[0047]** For measuring the flow of fluid out of the high pressure chamber 21 (through the outlet conduit 34), a flowmeter 26 (flow measuring unit) is provided. A manometer 27 is provided for measuring the pressure at the input of the core holder 22 or at the inlet side of the high pressure chamber 21, in particular in the inlet conduit 32.

**[0048]** In addition, there is a manometer 28 at the output of the core holder 22 or at the outlet side of the high pressure chamber 21, in particular in the outlet conduit

34.

**[0049]** A first valve 29, in particular a shutoff valve or stopcock, is arranged in the inlet conduit 32 for regulating or shutting off high pressure fluid routed to the high pressure chamber 21. A second valve 36, in particular a control valve or auto-regulating tap, is arranged in the outlet conduit 34, downstream of the manometer 28 and/or downstream of the flowmeter 26.

**[0050]** The test unit 20 can be named a device for testing the permeability of a core or core sample.

**[0051]** The core holder 22 with the heater 24 allow creating the required thermobaric conditions that correspond to those in an actual reservoir.

**[0052]** The deployment of the testing device is realized as follows: The pressure at the input of the core holder 22 is set to the actual reservoir pressure in the investigated reservoir. Once a filtration process of a working fluid through the tested sample or core 30 is established, the indication of the flowmeter 26 and the temperature in the high-pressure chamber 21, which is set equal to the temperature in the tested reservoir, are noted.

**[0053]** By regulating the pressure in the chamber with the control valve or tap 36 and/or the valve (stopcock) 29 at the input of the core holder 22, one obtains a pressure gradient at the core 30, which corresponds to a drawdown pressure.

**[0054]** For a settled drawdown pressure the hydraulic generator is enabled.

**[0055]** By changing (increasing) the amplitude and/or the frequency of the hydraulic generator 23, and noting the indications of measurement gauges after the initial transients due to amplitude and frequency changes, the permeability of the core 30 through the creation of fatigue cracks in the core material is increased. It is measured by the flow measured with flowmeter 26. The amplitude and frequency of the hydraulic generator 23 are changed so as to increase the flow through the sample, i.e. the flow measured by the flowmeter 26.

**[0056]** For assessing the changes in the permeability of the test core 30, the hydraulic generator 23 is temporarily switched off, and the permeability of the test core 30 is then measured. This can generally be done by using standard permeability estimation methods. Then, the hydraulic generator 23 is restarted and the amplitude and frequency can be increased further.

## Claims

1. Method for the recovery of oil and/or gas from a reservoir (10) by operating in a well (7) a pump (2) and a hydraulic pressure impulse generator (5),
wherein the method further comprises the step of determining, in a preliminary study in a test unit (20), a fluid pulse amplitude and a fluid pulse frequency of the hydraulic pressure impulse generator (5), and a total pressure (Pt) to be established in the well (7).

2. Method according to claim 1,
wherein in the preliminary study, in order to obtain values for the fluid pulse amplitude and the fluid pulse frequency of the hydraulic pressure impulse generator (5) and the total pressure (Pt) in the well (7), a fluid pulse amplitude, a fluid pulse frequency and a pressure in the test unit (20), in which a sample (30) is placed, are sequentially changed to values at which the sample (30) reaches a maximum permeability.

3. Method according to claim 1 or 2,
wherein in the preliminary study, a sample (30) representative of the reservoir (10) is exposed in the test unit (20) to a fluid pressure pulses.

4. Method according to of the preceding claims,
wherein in the preliminary study, conditions relative to pressure and/or temperature are established in the test unit (20), which are representative of the reservoir (10).

5. Method according to of the preceding claims,
wherein in the preliminary study, a fluid pulse amplitude and a fluid pulse frequency of a test hydraulic pressure impulse generator (23) of the test unit (20) are sequentially changed.

6. Method according to of the preceding claims,
wherein in the preliminary study, a pressure drop over a sample (30) is sequentially changed.

7. Method according to of the preceding claims,
wherein the total pressure (Pt) to be established in the well (7) is calculated as a sum of a mean pressure generated by a test hydraulic pressure impulse generator (23) of the test unit (20) and a pressure drop in the sample (30).

8. Method according to of the preceding claims,
wherein a drawdown pressure $\Delta P$ to be established during the extraction of oil and/or gas from the reservoir (10) is calculated by $\Delta P = (P_r - Pt)$, in which $P_r$ is a reservoir pressure and Pt is the total pressure in the well (7).

9. Method according to of the preceding claims,
wherein during the extraction of oil and/or gas from the reservoir (10), a drawdown pressure $\Delta P$ calculated by $\Delta P = (P_r - Pt)$, in which $P_r$ is a reservoir pressure and Pt is the total pressure in the well (7), is maintained within predetermined limits.

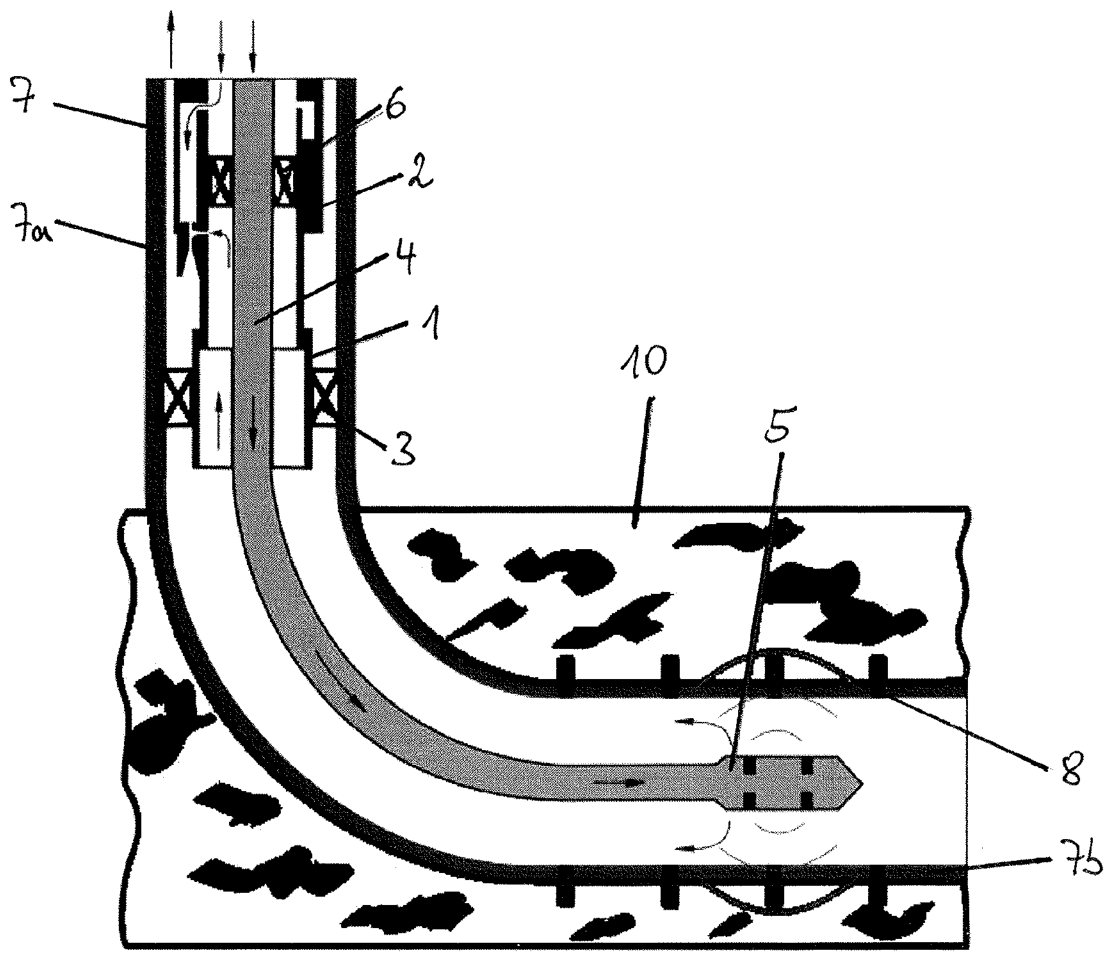
10. Method according to of the preceding claims,
wherein during the extraction of oil and/or gas from the reservoir (10), the fluid pulse amplitude and/or the fluid pulse frequency of the hydraulic pressure impulse generator (5) is changed during the opera-

tion of the pump (2) and the hydraulic pressure impulse generator (5) in the well (7).

**11.** Method according to of the preceding claims, wherein during the extraction of oil and/or gas from the reservoir (10), a drawdown pressure $\Delta P$ calculated by $\Delta P = (P_r - Pt)$, in which $P_r$ is a reservoir pressure and Pt is the total pressure in the well (7), is maintained within predetermined limits by changing at least the fluid pulse amplitude and/or the fluid pulse frequency of the hydraulic pressure impulse generator (5).

**12.** Method according to of the preceding claims, wherein during the extraction of oil and/or gas from the reservoir (10), a drawdown pressure $\Delta P$ calculated by $\Delta P = (P_r - Pt)$, in which $P_r$ is a reservoir pressure and Pt is the total pressure in the well (7), is maintained within predetermined limits by changing at least a suction pressure of the pump (2).

Fig. 1



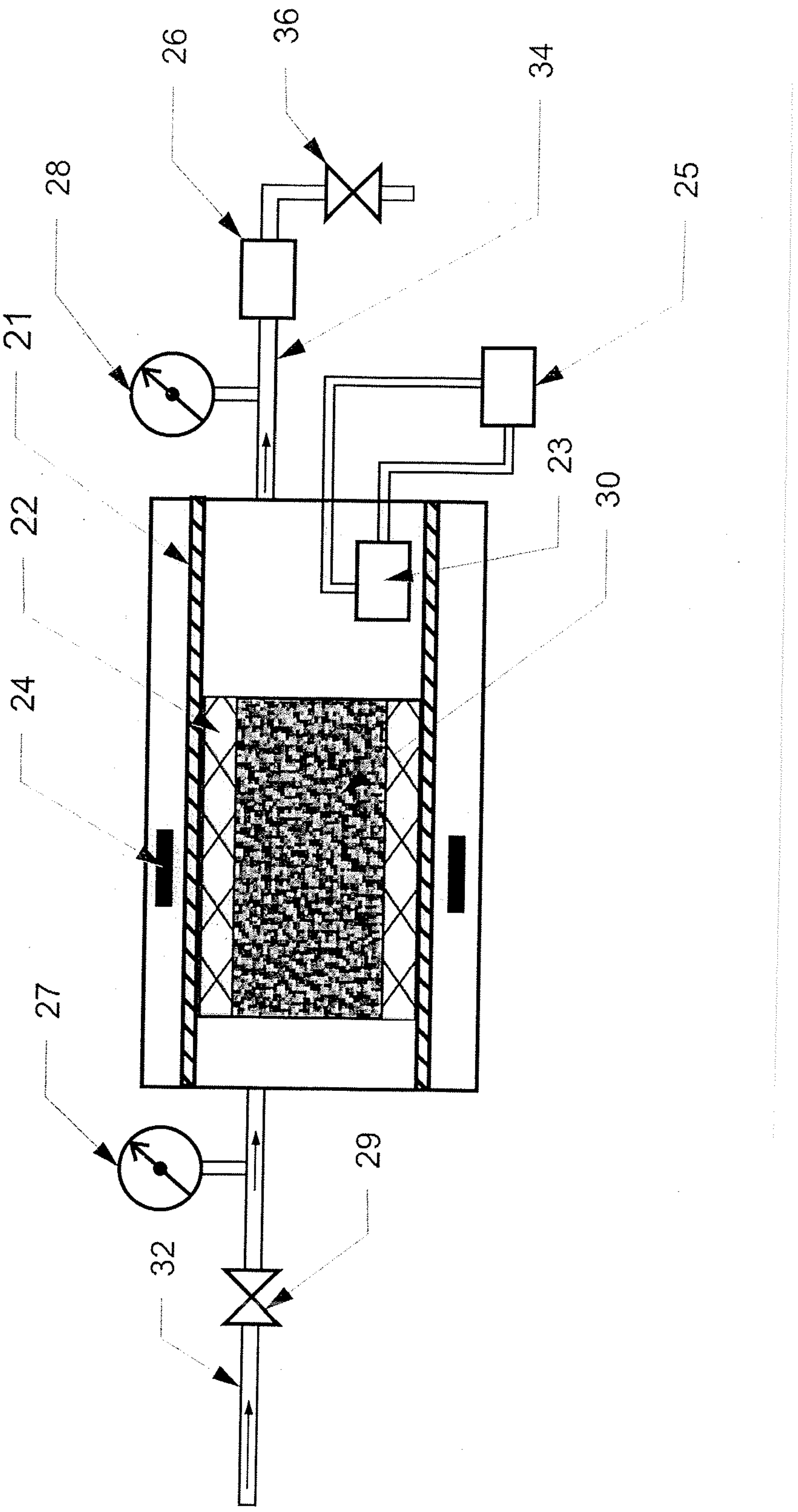



Fig. 2

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# EUROPEAN SEARCH REPORT

Application Number
EP 15 16 9228

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