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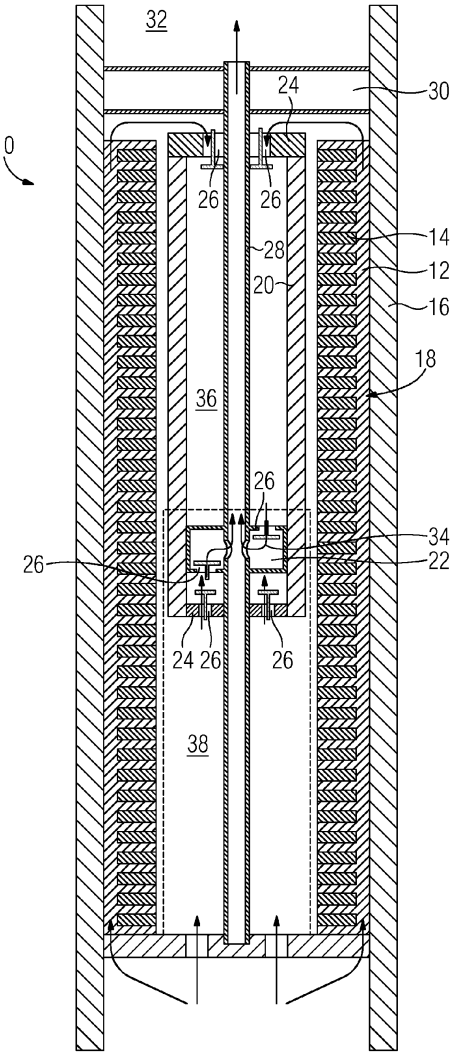
(54) **Device for fracturing the formation rock of a well**

(57) The invention relates to a device (10) for fracturing the formation rock of a well by generating hydraulic pressure pulses within the wellbore, comprising a chamber (20) and a piston (22) moveable relative to each other and a linear motor (18) for driving the relative motion of chamber (20) and piston (22).

FIG 1



EP 2 730 740 A1

Description

[0001] The invention relates to a device for fracturing the formation rock of a well.

[0002] To improve the fluid flow from oil or gas wells with low formation pressure or low formation permeability, hydraulic fracturing is usually applied. A well-known approach is to pump a fracturing fluid down the wellbore at pressures of 500 to 1000 bar. This leads to the development of cracks within the formation and to the extension of existing crack systems, providing flow paths for the fluids from the formation to the wellbore.

[0003] Since the handling of such pressures is problematic and can be dangerous, it is attempted to reach the desired fracturing at more gentle conditions. One approach is the so called pulsed pressurization method, based on creating hydraulic pressure pulses from within the well. This method works particularly well in gas shales composed of relatively ductile rocks.

[0004] A device for pulsed pressurization of wellbores is disclosed in US 3 422 760 A. The device consists of a housing with several gas-generating charges, which can be lowered into the wellbore. With the device in place, the charges are ignited and rupture pressure seals at predetermined pressures, thereby creating the desired shock waves within the formation rock.

[0005] The use of charges to generate the pressure waves renders such devices single-use only. If further fracturing is desired, the device has to be removed from the wellbore and replaced. This leads to costly delays in the completion or treatment process of the well.

[0006] It is therefore the objective of the present invention to provide a device for fracturing the formation rock of a well which is reusable and can provide an unlimited amount of pressure pulses within the wellbore.

[0007] This objective is achieved by a device according to claim 1.

[0008] Such a device for fracturing the formation rock of a well by generating hydraulic pressure pulses within the wellbore comprises a chamber and a piston moveable relative to each other and a linear motor for driving the relative motion of chamber and piston.

[0009] The device can be lowered into the wellbore, where the relative movement of piston and chamber is initiated. Due to the low compressibility of the fluid in the bore, such movements lead to high pressure waves which in turn lead to the desired fracturing of the formation rock. Since the device can be precisely placed within the wellbore, fracturing can be finely controlled. The use of an electric linear motor to drive the motion allows for an unlimited number of pulses without the need to replace the device, thereby saving time and costs.

[0010] The relative movement of piston and chamber can be precisely controlled via the electric linear motor. By adjusting frequency and current, the fracturing parameters can be fine-tuned to the geological conditions in the formation rock, thus improving the fracturing result.

[0011] In a further embodiment of the invention, the piston is fixed relatively to the linear motor, while the chamber is movably supported. Alternatively, the chamber can be fixed, while the linear motor drives the movement of the piston.

[0012] Preferably, the device comprises an end plate oriented upwards when the device is inserted into the wellbore. This plate is designed to provide a smooth fit of the device within the well's casing and separates the space above the device from the space below, so that the generated pressure waves are confined to the borehole area below the device. In this manner, the energy of the pressure waves are directed more efficiently to the formation, yielding better fracturing results.

[0013] In a further preferred embodiment of the invention, the device comprises a first fluid communication channel connecting the space between the piston and the end plate to the space above the end plate. This allows for pressure equilibration after a movement cycle of the device is complete. The same role is filled by a second fluid communication channel connecting the space below the piston to the space above the end plate. The fluid communication channels are preferably of a small diameter compared to the wellbore diameter, so that the pressure buildup is not hampered.

[0014] It is further of advantage, if the first and/or second fluid communication channel comprises at least one check valve preventing backflow from the space above the end plate into the respective other space connected to the fluid communication channel, so as to better control the fluid flow during device operation.

[0015] In the following section, the invention and its embodiments is further explained with reference to the drawings, which show in:

FIG 1 a schematic representation of an embodiment of a device according to the invention with moveable chamber and fixed piston; and

FIG 2 a schematic representation of an alternative embodiment of a device according to the invention with fixed chamber and moveable piston.

[0016] A device 10 for fracturing the formation rock of oil or gas wells comprises a cylindrical mantle 12 which fits the inside of the well's casing 14. The stator part 16 of an electrical linear motor 18 is mounted on the inner surface of the mantle 12.

[0017] In the embodiment of FIG 1, the moveable part 20 of the linear motor 18 forms a chamber enclosing a fixed piston 22. The chamber 20 is closed against the inner volume of the casing 14 by end plates 24, which contain check valves 26 to allow the influx of fluid into the chamber 20.

[0018] The piston 22 is fixed to a hollow tube 28 which extends throughout the device 10 and through the device's end plate 30 and opens into the space 32 in the casing 14 above the device 10. The tube 28 further connects to the hollow interior 34 of the piston 22, which in

turn is connected to the space 36 above and the space 38 below the piston with respective check valves 26 allowing fluid to enter the piston 22.

[0019] When an alternating current is applied to the stator 16, the chamber 20 moves periodically up and down relative to the piston 22, alternatively compressing the fluid in the spaces 36, 38, while the check valves 26 allow for a slow reequilibration of pressure. The compression waves generated this way propagate through the borehole and into the formation rock, where they induce the desired fracturing.

[0020] An alternative design is depicted in FIG 2. In this case, the chamber 20 is fixed relative to the stator 16, while the piston 22 forms the moveable part of the linear motor 18. In contrast to the embodiment shown in FIG 1, the piston 22 is solid and moves on a solid axis 40. The space 36 above the piston 22 is connected to the space 32 above the device 10 by a first tube 42 with a check valve 26 opening to the space 32. In a similar manner, the space 38 below the piston 22 connects to the space 32 via a second tube 44 with a check valve 26 also opening to the space 32. Another check valve 26 in the lower end plate 24 of the chamber 22 allows fluid to enter the lower space 38, whereas a check valve 26 in the upper end plate 24 of the chamber serves as point of entry for fluids into the upper space 36.

[0021] Analogous to the embodiment of FIG 1, applying a current to the linear motor 18 induces movement of the moveable part, in this case the piston 22. Here again, this leads to the generation of pressure waves which penetrate the formation rock and lead to fracturing.

[0022] By manipulation amplitude and frequency of the current applied to the linear motor 18, various patterns of pressure waves can be generated and optimized depending on the geological conditions in the formation. This allows for particularly good fracturing results in ductile rocks, such as oil shales. Furthermore, it is possible to create large fractures at the beginning of the fracturing process and, by changing the frequency and amplitude later, switch to the generation of microfractures in the near wellbore zone of the formation, thus improving the permeability of the rock and the resulting flow out of the reservoir.

[0023] The localized application of pressure by using the device 10 helps to constrain the fracturing to the oil or gas bearing formation itself and to avoid damage to the overburden, alleviating environmental concerns associated with conventional fracturing techniques, such as the contamination of aquifers by fracturing fluids.

Claims

1. Device (10) for fracturing the formation rock of a well by generating hydraulic pressure pulses within the wellbore, comprising a chamber (20) and a piston (22) moveable relative to each other and a linear motor (18) for driving the relative motion of chamber (20) and piston (22).

2. Device (10) according to claim 1, **characterized in that** the piston (22) is fixed relatively to the linear motor (18).

3. Device (10) according to claim 1, **characterized in that** the chamber (20) is fixed relatively to the linear motor (18).

4. Device (10) according to any of the preceding claims, **characterized in that** the device (10) comprises an end plate (30) oriented upwards when the device (10) is inserted into the wellbore.

5. Device (10) according to claim 4, **characterized in that** the device (10) comprises a first fluid communication channel (42) connecting the space (36) between the piston (22) and the end plate (30) to the space (32) above the end plate (30).

6. Device (10) according to claim 4 or 5, **characterized in that** the device (10) comprises a second fluid communication channel (44) connecting the space (38) below the piston (22) to the space (32) above the end plate (30).

7. Device (10) according to claim 5 or 6, **characterized in that** the first and/or second fluid communication channel (42, 44) comprises at least one check valve (26) preventing backflow from the space (32) above the end plate (30) into the respective other space (36, 38) connected to the fluid communication channel (42, 44).

FIG 1

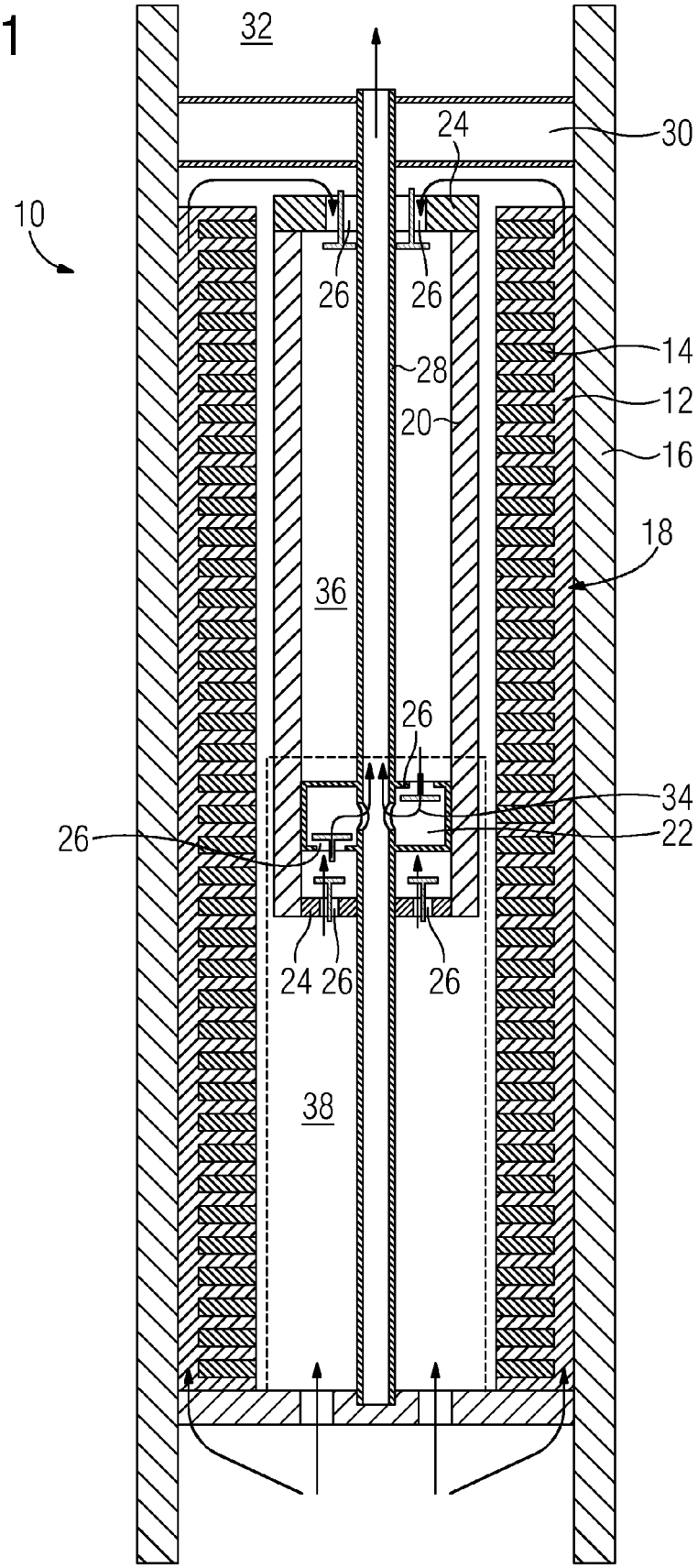
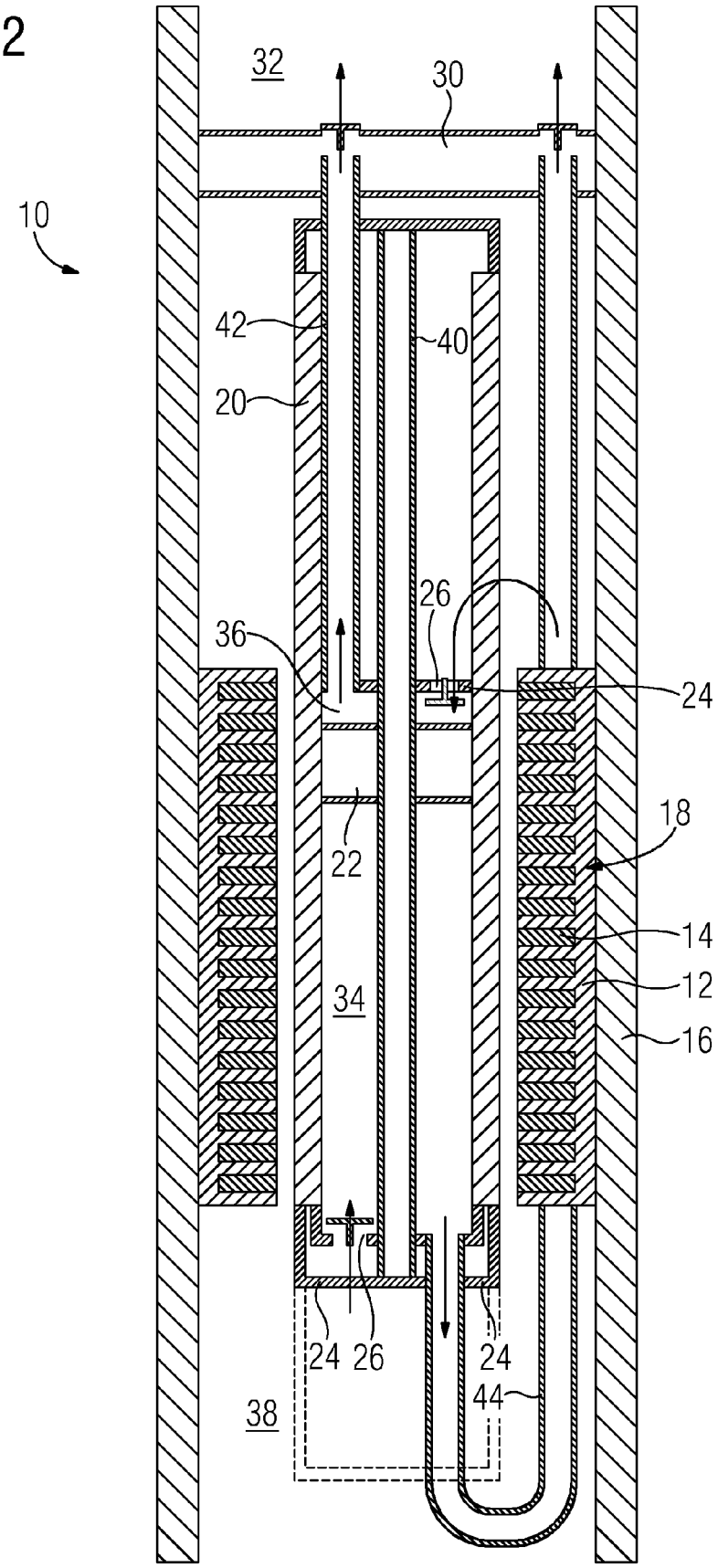


FIG 2



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EUROPEAN SEARCH REPORT

Application Number
EP 12 19 1755

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
A,D	US 3 422 760 A (MOHAUPT HENRY H) 21 January 1969 (1969-01-21) * column 7, lines 3-36 * * figures 1-5 * -----	1-7	INV. E21B43/26
A	US 2005/260089 A1 (HAHN DETLEF [DE] ET AL) 24 November 2005 (2005-11-24) * abstract * -----	1-7	

TECHNICAL FIELDS SEARCHED (IPC)

E21B

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	18 March 2013	Schouten, Adri

CATEGORY OF CITED DOCUMENTS

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ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 12 19 1755

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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18-03-2013

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EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

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