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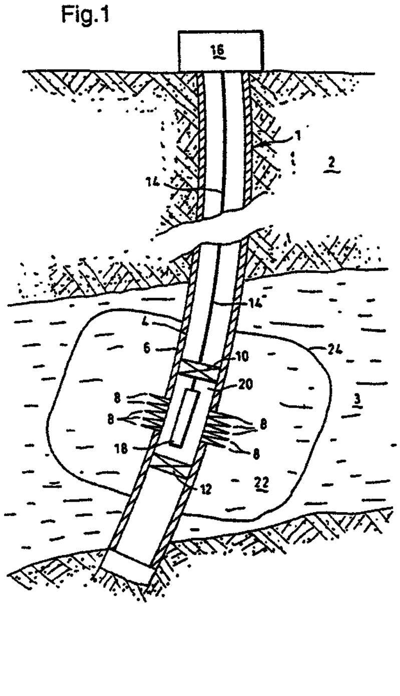
(54) **Titre :** Method of improving the permeability of an earth formation.

(57) **Abrégé :**

A method of improving the permeability of an earth formation zone surrounding a wellbore formed in the earth formation, the method comprising pumping a selected liquid via the wellbore into said earth formation zone so as to create a body of liquid extending into the wellbore and into the pores of said zone, lowering a shock wave generator into the body of liquid in the wellbore, and inducing the shock wave generator to generate a shock wave in the body of liquid.

Fig.1



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The present invention relates to a method of improving the permeability of an earth formation zone surrounding a wellbore formed in the earth formation. In the practice of producing hydrocarbon fluid from an earth formation via a wellbore to a production facility at surface, a perforated casing or liner is generally installed in the wellbore. The hydrocarbon fluid flows via the pores of the formation towards the casing or liner and via the perforations thereof into the wellbore.

A problem frequently encountered is that the permeability of the earth formation is relatively low resulting in reduced production capacity of the wellbore. One cause of such reduced permeability is the presence of formation illite in the pores. Formation illite is a clay mineral which partially occupies the interstices between the rock particles. The presence of illite in the form of needles or platelets significantly reduces the ability of hydrocarbon fluid to flow through the pores.

The method and shock wave generator according to the preamble of claims 1 and 3 are known from US patent 3,589,442.

The known method and device are designed to unplug perforations shot into an earth formation surrounding a water injection or oil and/or gas production well.

The known method is not suitable to increase the permeability of an oil and/or gas bearing formation surrounding the perforations since any gas pockets that may be present or formed in the hydrocarbon fluids will quickly dampen the generated shock wave and inhibit transmission of the shock wave deep into the oil and/or gas bearing formation.

US patent 5,005,649 discloses a method for fracturing a formation wherein a pulse of pressurized gas squeezes a fracture fluid and proppant into fractures formed in the surrounding formation. In the known method the fracture fluid and proppant are not pumped into the formation before releasing the gas pulse and any shock wave generated in the pore fluids of the formation will be quickly dampened by any pockets of gas that may be present in the pores of the formation.

US patent Re 23,381 discloses another method for unplugging perforations in the inflow zone of an oil well wherein cyclic acoustic vibrations release depositions from said perforations.

All these prior art references are designed to open or reopen fractures in the direct vicinity of the well, but are not suitable to improve the permeability of an oil and/or gas bearing formation away from the well since any gas pockets in the formation pores will quickly dampen the generated shock waves.

It is an object of the invention to provide an improved method and shock wave generator for improving the permeability of an earth formation zone surrounding a wellbore formed in the earth formation.

In accordance with the invention this is accomplished by the method according to the characterizing portion of claim 1 and the shock wave generator according to the characterizing portion of claim 3.

It is thereby achieved that the shock wave travels through the pores of the formation where the body of liquid is present and thereby destroys the illite particles present in the pores.

The invention will be described further in more detail and by way of example with reference to the accompanying drawings in which

Fig. 1 schematically shows an embodiment of a wellbore used in applying the invention;

Fig. 2 schematically shows a device for use in the embodiment of Fig. 1;

Fig. 3 schematically shows a first alternative device for use in the embodiment of Fig. 1; and

Fig. 4 schematically shows a second alternative device for use in the embodiment of Fig. 1.

In the drawings like reference numerals relate to like components.

Referring to Fig. 1 there is shown a wellbore 1 formed in an earth formation 2 having a hydrocarbon fluid reservoir 3, the wellbore being provided with a casing 4 fixed in the wellbore 1 by a layer of cement 6. The casing 4 is provided with a plurality of perforations 8 at the level of the hydrocarbon fluid reservoir 3. An upper packer 10 is arranged in the casing above the perforations 8, and a lower packer 12 is arranged in the casing below the perforations 8. An electric cable 14 extends from a control facility 16 at surface through the casing 4 and through an opening (not shown) provided in the upper packer 10 to a shock wave generator 18 arranged in the space 20 between the packers 10, 12. The space 20 is filled with a body of brine 22 which extends via the perforations 8 into the hydrocarbon fluid reservoir 3 up to an interface 24 with the hydrocarbon fluid present in the hydrocarbon fluid reservoir 3.

In Fig. 2 is shown in more detail the shock wave generator 18 including a tubular housing 24 formed of a first tubular part 26 and a second tubular part 28 connected to the first tubular part 26 by a screw connection 30 whereby a shear disc 32 is biased between the first and second tubular parts 26, 28. The first tubular part is provided with an end cap 34 and a plurality of openings 36. The second tubular part is closed by a plug assembly 38 screwed in the second tubular part by means of screw connection 40. The plug assembly 38 is provided with a bore 42 in which an ignition device 44 connected to the electric cable 14, is arranged. A charge of deflagrating material 46 is arranged in the second tubular part 28, between the ignition device 44 and the shear disc 32.

In Fig. 3 is shown a first alternative shock wave generator 47 which is substantially similar to the embodiment of Fig. 2, the difference being that the shear disc 32 forms a primary shear disc and that each opening 36 is provided with a secondary shear disc 48.

In Fig. 4 is shown a second alternative shock wave generator 49 which is substantially similar to the embodiment of Fig. 2, except that the plug assembly, the ignition device and the deflagrating charge have been replaced by a piston assembly 50 including a cylinder 51 in the form of second tubular part 28 and a piston 52 arranged in the cylinder 51. The piston 52 is movable relative to the cylinder 51 in the direction of the shear disc 32 so as to compress a body of gas 54 present between the piston 52 and the shear disc 32. The piston assembly 50 furthermore includes a plug 55 screwed into the cylinder 51 and provided with a central bore 56 having an internal shoulder 58. A spring assembly 60 is arranged between the piston 52 and the plug 54, the spring assembly 60 being compressed by a threaded tie rod 62 at one end thereof connected to the piston 52 and at the other end thereof extending through the bore 56 and being retained at internal shoulder 58 by an explosive nut 64 connected to the electric cable 14.

During normal operation brine is pumped into the wellbore, the brine flowing via the perforations 8 into the hydrocarbon fluid reservoir 3. Pumping is stopped after a selected quantity of brine has flown into the hydrocarbon reservoir 3 so that the body of brine 22 is formed. Next the lower packer 12, the shock wave generator 18, the upper packer 10 and the electric cable 14 are installed in the wellbore 1.

The shock wave generator 18 (shown in Fig. 2) is then activated by transmitting a selected electric signal through the cable 14, which signal induces the charge of deflagrating material 46 to detonate. As a result the pressure in the second tubular part 28 rises to a level at which the shear disc 32 shears. Upon shearing of the shear disc 32, a shock wave occurs in the first tubular part 26 which travels through the openings 36 into the part of the body of liquid 22 present in the wellbore 1, and from there via the perforations 8 into the part of the body of liquid present in the hydrocarbon fluid reservoir 3. As the shock wave travels through the pores of the earth formation, the illite particles present in the pores are destroyed by the shock wave. This effect is even enhanced by reflection of the shock wave at the interface 24.

Normal operation using the first alternative shock wave generator 47 is similar to normal operation using the shock wave generator 18, except that additionally the secondary shear discs 48 are sheared off upon the occurrence of the shock wave in the first tubular part 26.

Normal operation using the second alternative shock wave generator 49 is similar to normal operation using the shock wave generator 18, except that the pressure rise in the second tubular part is now created by transmitting a controlled electric signal through the cable 14 in order to detonate the explosive nut 64. Upon detonation of the nut 64, the tie rod 62 breaks thereby inducing the spring assembly 60 to move the piston 52 in the direction of the shear disc 32 and to compress the body of gas 54. As a result the pressure in the second tubular part 28 rises to the level at which the shear disc 32 shears.

It will be appreciated that the shock wave generation characteristics of the embodiments of Figs. 2, 3 and 4 are mutually different, therefore either of these embodiments can be selected in accordance with the required characteristics.

Any suitable water- and pressure proof deflagrating material can be selected for the charge of deflagrating material, for example RDX.

CLAIMS

1. A method of improving the permeability of an earth formation zone (3) surrounding a wellbore (1) formed in the earth formation, the method comprising

- pumping a selected liquid (22) via the wellbore (1) into said earth formation zone so as to create a body of liquid (22) extending into the wellbore (1) and into the pores of said zone;
- lowering a shock wave generator (18) into the body of liquid in the wellbore (1); and
- inducing the shock wave generator (18) to generate a shock wave in the body of liquid (22), characterized in that the method further comprises allowing a hydrocarbon earth formation fluid to flow into the wellbore (1) after induction of the shock wave in the body of liquid (22).

2. The method of claim 1, wherein said liquid (22) is selected from water, brine and hydrocarbon liquid.

3. A shock wave generator for use in the method of any one of claims 1-2, comprising a housing having a pressure chamber (4) provided with means (19) for generating a pressure increase in the pressure chamber, the housing being provided with at least one opening (14), characterized in that said opening (14) is separated from the pressure chamber (4) by at least one shear member (32,48).

4. The shock wave generator of claim 3, wherein the means (19) for generating a pressure increase comprises one of a charge of explosive material and a charge of deflagrating material (46).

5. The shock wave generator of claim 3 or 4, wherein the housing is provided with a diffuser chamber separated from the pressure chamber by a shear disc, each said opening (14) being provided in the wall of the diffuser chamber (26).

6. The shock wave generator of claim 5, wherein the means for generating a pressure increase comprises a cylinder (51) and a piston (52) movable relative to the cylinder (51) in a direction so as to compress a body of gas (54) present between the piston (52) and the shear disc (32).

7. The shock wave generator of claim 6, further comprising spring means (60) arranged to move the piston (52) from a first position to a second position thereof so as to compress the body of gas (54), the piston (52) being retained in the first position by a tie rod (62) releasable by explosive activation.

8. The shock wave generator of any one of claims 5-7, wherein said shear disc (32) forms a primary shear disc, and wherein each said opening is provided with a secondary shear disc (48).

Fig.1.

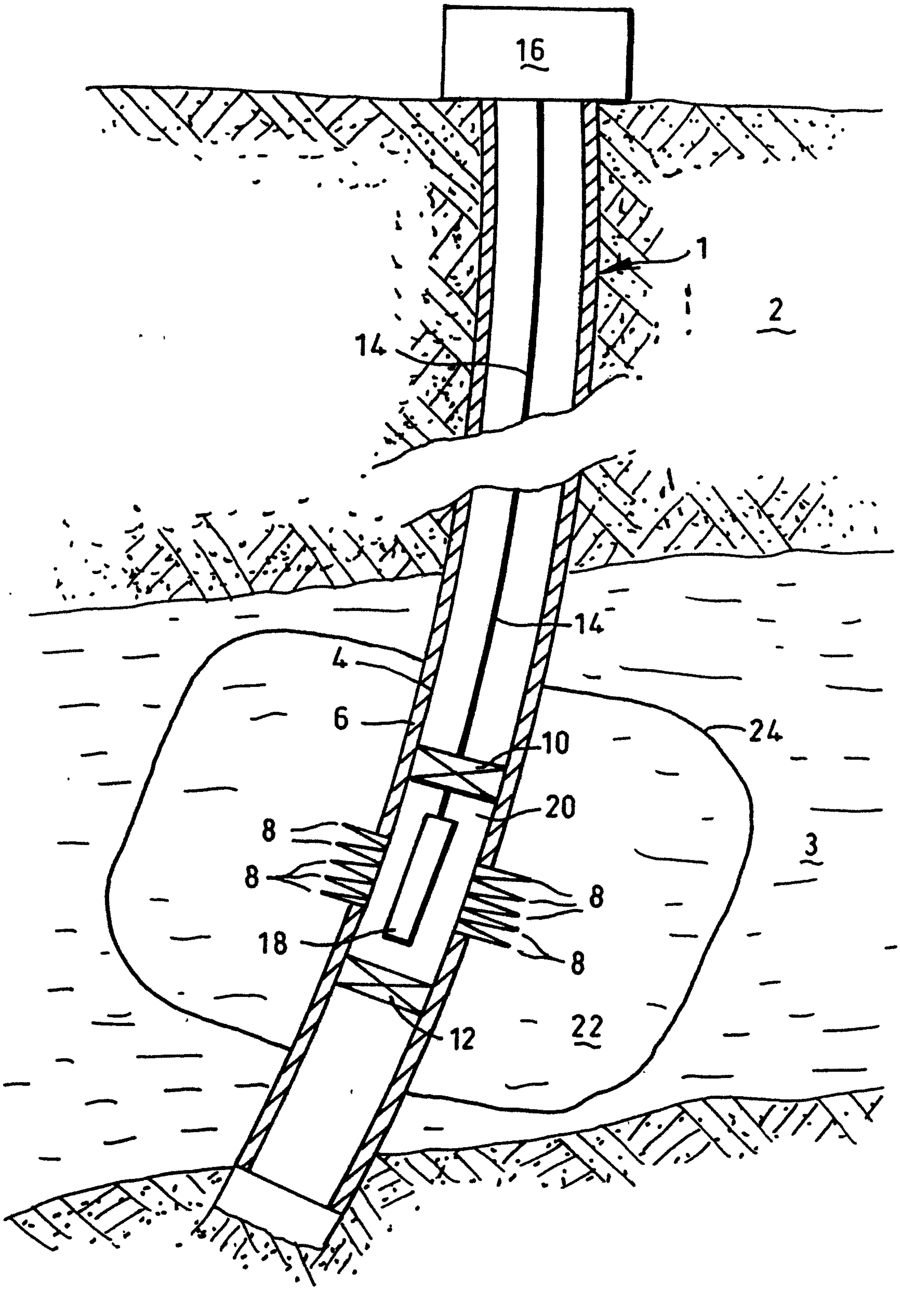

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Fig.2.

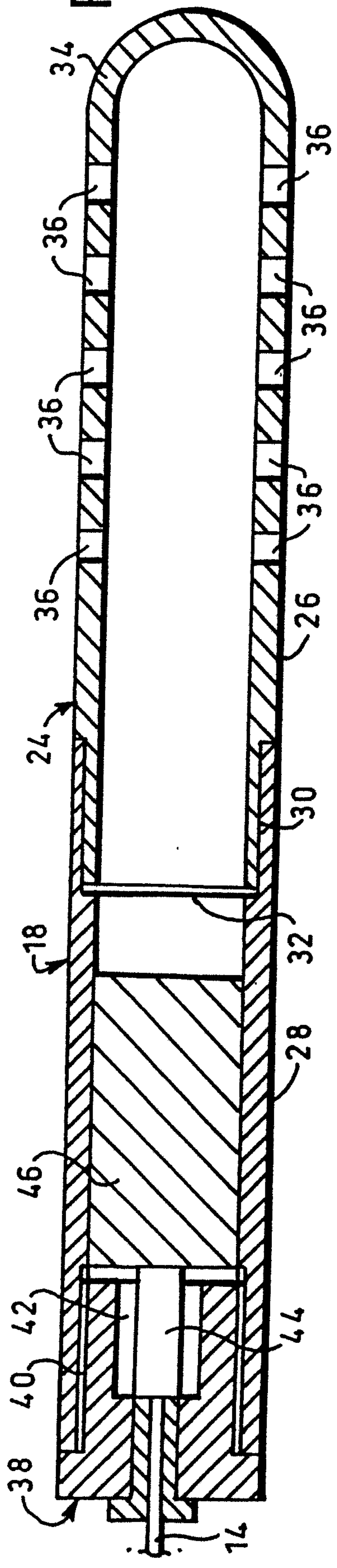

Fig.3.

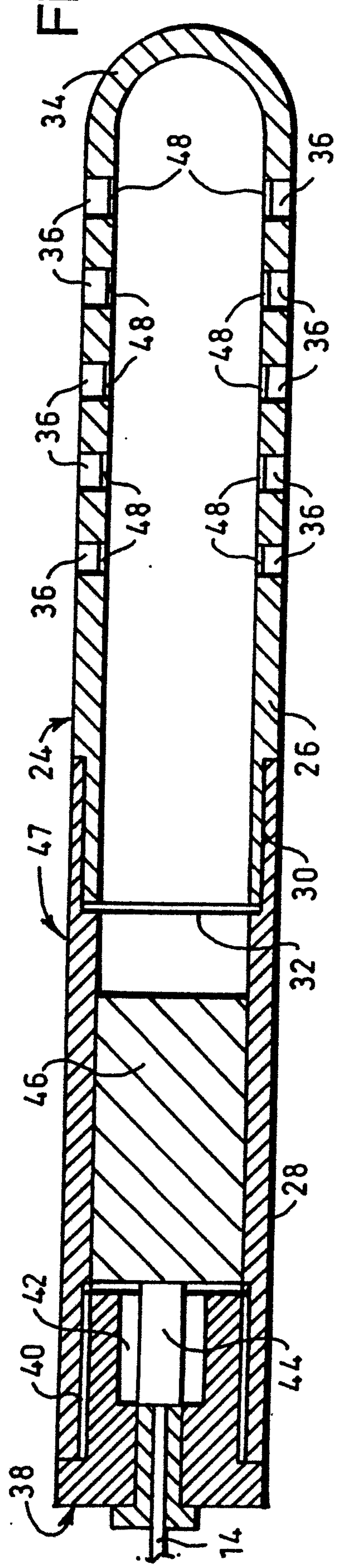

Fig.4.