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(21) International Application Number: PCT/NO00/00125 (22) International Filing Date: 14 April 2000 (14.04.00) (30) Priority Data: 19991872 20 April 1999 (20.04.99) NO (71) Applicant (for all designated States except US): SUBSURFACE TECHNOLOGY AS [NO/NO]; P.O. Box 10 Haaland Aust, N-4349 Bryne (NO). (72) Inventor; and (75) Inventor/Applicant (for US only): HANSEN, Henning [NO/NO]; Kvernkalen 8, N-4070 Randaberg (NO). (74) Agent: ONSAGERS AS; P.O. Box 265 Sentrum, N-0103 Oslo (NO).		(81) Designated States: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CR, CU, CZ, DE, DK, DM, DZ, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, TZ, UA, UG, US, UZ, VN, YU, ZA, ZW, ARIPO patent (GH, GM, KE, LS, MW, SD, SL, SZ, TZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG). Published <i>With international search report.</i> <i>Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.</i>
(54) Title: OIL WELL INTERZONE LEAK DETECTION		
(57) Abstract		
Apparatus and method for detecting leaks in packers around casings in oil wells. A coiled tubing (2) carries a sectioned container (3) with doses of emulsifiable tracer fluid (9), a set of double packers (4) for internal sealing between the casing (1) and the coiled tubing, and a detector (6). This is lowered, with the oil flow (7) stopped, to the zone-isolating packers (5A, 5B), where the coiled tubing's packers (4) are expanded. Production flow (7) is then started, and a pressure-controlled force (8) expels a dose of tracer fluid (9) from container (3) into the oil flow from the reservoir. If there is leakage past the lowest packer (5A), the tracer fluid (9) will be sucked round and past it and follow the oil flow (7) past a detector (6) which reveals any leakage. The second lowest packer (5B) is then tested and so on. The tracer fluid (9) contains dyes, ion-bearing metallic salts or chips, radioactive fragments, and/or gases.		

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Oil Well Interzone Leak Detection

The invention relates to a method for using tracer fluid for detecting leaks in packers around casings which extend down into oil-bearing subsurface formations.

5 In many cases there are several oil-bearing strata forming individual zones in an oil well. Each zone may extend up to 1500 m, and each well may have up to 16 zones. It is desirable to monitor the relationships between the different zones and their interaction with the well.

Various techniques for monitoring various aspects of the drilling and operation of oil wells are known, using tracers of various kinds.

10 In some of these techniques, the tracer is injected from the surface to the location or locations which require to be checked. For example, US 4,972,704, and US 5,031,697, Wellington et al/Shell describe a method of detecting leaks in/around the packers which are installed between the outer casing and the production tubing inserted therein, and also of establishing whether valves placed on production
15 tubing in a well are open or closed.

In others of these techniques, the tracer is lowered into the well and injected at the location or locations which require to be checked. For example, US 4,166,216, Cubberly/Schlumberger describes a method for measuring the flow pattern in a well. Oil-miscible and water-miscible radioactive tracers are injected from the
20 end of a tool lowered into the well. US 5,723,781, Pruett & Finflay describes a method for measuring the flow pattern in a well by injecting radioactive tracer. And US 4,196,619, Collins/USA-NASA describes a method for determining the permeability of a stratum in a well, in which an elongated probe is extended through a side hole from the main bore, a chain of seals is formed along the bore to
25 divide it into chambers, tracer is injected into one of the chambers, and the main bore pressure is raised or lowered relative to the pressure in the stratum. Leakage of tracer through the surrounding stratum from that chamber to others along the chain is detected.

The individual zones in each well may belong to different operating companies,
30 and even different nationalities. The operations of the various individual zones must therefore be isolated from each other, for economic requirements and other conditions. However, in some cases there are substantial pressure differences between individual oil-bearing strata. Undesirable pressure equalizing between the strata is therefore liable to occur, causing oil and possibly water to migrate
35 between the strata. This can result in lower oil production, in addition of course to the loss of isolation between the zones. It is therefore desirable that the strata

should be shielded from one another. Zonal isolation is thus necessary in order to have control over the individual zones. This can be achieved by the use of zone-isolating or sealing packers, so-called External Casing Packers (EC packers or ECPs).

- 5 As mentioned above, there are various techniques known for monitoring the operation of oil wells. However, at present there are no methods for checking that installed zone-isolating packers are actually tight, even when they are new. It is not possible to determine whether zone-isolating packers, individually or collectively, have expanded to provide the sealing function they actually should have. Also, it cannot be established whether zone-isolating packers are leaking, in
10 which case how much, and which packer or packers are leaking. At present no corrective/sealing measures are provided against leaks. In fact, the probability that the packers are working as they are intended to may be as low as 30%.

- As a result, some companies which intend to share the production yield in a well
15 have considered stopping the installation of such zone-isolating packers altogether, and sharing the production according to prior agreement instead. In many cases such uncontrolled production can be extremely wasteful, since it results in the migration of large quantities of oil from zones at high pressure to zones at lower pressure without any oil being produced. In the same way, the possibility of
20 controlling and closing off water-bearing zones is lost, with the result that the percentage of oil in the produced fluid flow will gradually drop. When the water admixture in the upstream reaches 90% the whole well is shut down, even though there still may be zones providing a very high percentage of oil which could have been exploited.

- 25 The general object of the invention is to provide a technique for enabling the testing of zone-isolating packer in oil wells.

- According to one aspect the invention provides a method of detecting leaks in packers round casings in oil wells characterized by forming a seal in the well casing at the level of the packer, injecting a tracer fluid into the well below the
30 seal, causing oil flow from the well, and monitoring the flow for the presence of tracer fluid. Preferably the process is repeated at each packer in succession up the well.

- Simple detection can be carried out after a suitable interval by inspecting the oil flow visually on deck, by, e.g., using dyes as a tracing element. This simple form
35 of detection is unlikely to enable the size of the leak to be quantified, but it will still provide an indication of the leakage situation in the well. Preferably,

however, a detector is located above the packer means for detecting the tracer fluid.

According to another aspect the invention provides apparatus for detecting leaks in packers round casings in oil wells, characterized in that the apparatus is insertable
5 down a well and comprises packer means operable to close off the well and tracer fluid container means operable to inject tracer fluid into the well below the packer means.

Preferably the apparatus is carried on the end of jointless coiled tubing, the packer means comprise a double set of cylindrically enclosing, expandable packers, and
10 the container means comprises a plurality of sections.

The present technique can be used for continuous inspection by means of, for example, annual, sequential testing of each individual installed zone-isolating packer in an oil well in order to ascertain if there are any leaks; the technique also permits a quantitative detection of such leaks.

The technique is based on adding to the oil flow a tracer which, in the event of any leakage of oil past each of the ostensibly sealing zone-isolating installed packers, will thereby reveal and localize any leaks. The tracer is preferably a fluid which emulsifies or is dissolved or mixed in the oil-bearing production flow, and may contain dyes, ion-bearing metallic salts, metallic chips, radioactive fragments,
15 gases or combinations, which signal their existence to one or more down-hole detector elements adapted thereto. In addition to indicating any such leak, the
20 detector will normally also be capable of quantifying the size of the leak.

Apparatus for detecting interzone leaks in an oil well and its method of operation will now be described by way of example and with reference to the drawings, in
25 which:

Fig. 1 is a vertical section through an oil well containing interzone leak detection means; and

Figs. 2 to 5 show various stages of operation of the apparatus.

Fig. 1 shows a well comprising a helically perforated casing 1 which is established
30 in an oil-bearing formation having three zones Z1 to Z3. These zones are separated by means of isolation packers 5A and 5B; packer 5A is furthest from the production deck, and second furthest is isolation packer 5B, matching the intermediate oil-producing zone Z2. Such ECP packers are usually 3 to 5 m in length, cylindrically enclosing the casing, and consist of a cement mass which
35 provides a sealing effect between the rock masses in the formation and the casing.

Packer 5A provides a good seal, isolating zone Z1 from zone Z2. Packer 5B is leaky, permitting a leakage flow past the packer, and thereby from zone Z2 to zone Z3. A pressurized oil flow of this kind will in time erode material, thereby expanding the area which permits such undesirable oil leakage.

5 To detect the occurrence of leaks past the packers, a leak detector is used. This comprises a jointless coil tubing 2, inserted into the casing 1, whose outer end is equipped with three elements which can be activated from the production deck: a double set of cylindrically enclosing, expandable coil tubing packers 4 (CT
10 packers), a sectioned tracer fluid container 3, and a detector 6. The detector measures the presence of tracer fluid and signals both the presence of a leak and its intensity. CT packers are installed by internal pressure in coiled tubing by means of an up/down movement of the coiled tubing, by passing electric power down through the coiled tubing, by wireless telemetric commands from the surface or by other methods.

15 The coil tubing 2 is inserted into the casing 1 by means of known measuring and control technology to the place where the lowest isolation packer 5A is located. After the oil flow has been stopped, the coil tubing's double packers 4 are expanded and pressure-tested in order to eliminate leakage therein. Pressure-controlled force is then used to burst or explode one of a plurality of sectioned
20 containers 3 containing traceable fluid 9, which is thus injected into the oil 7 in zone Z1 below the zone-isolating packer 5A. Oil flow is then resumed.

If the packer 5A is tight, then the oil flow will be solely from the zones above the packer, i.e. zones Z2 and Z3, and this oil flow will contain no tracer. However, if
25 the packer 5A is not tight, some of the oil flow will be past the packer 5A from zone Z1, and the traceable fluid 9 will flow up together with this oil flow 7 from zone Z1. The presence of tracer fluid 9 in the oil flow 7 will inform the detector 6 that there is a leak through the area around the tested packer 5A, and the amount of tracer fluid, e.g. measured per time unit, will determine the intensity and thereby the volume of the leakage.

30 Instead of using a detector 6, a simple form of detection can be carried out by visually ascertaining on deck whether oil produced after a calculated interval will appear, e.g., in a coloured state. This will require greater amounts of tracer fluids for each test, and quantification of the size of the leak will be difficult or impossible.

35 Figs. 2 to 5 show the procedure in more detail. Fig. 2 shows the coiled tubing 2 inserted in the casing 1 containing a sectioned container 3 holding one or more doses of traceable fluid 9, a double set of expandable coiled tubing packers 4, and a

detector 6. The oil production flow 7 has been stopped at the start of the test. Fig. 3 shows pressure testing of the double set of coiled tubing packers 4 after they have been expanded by known control technology to provide a sealing function. The oil production flow 7 is still at a stop. Fig. 4 shows the situation after the oil
5 production flow 7 has been started. The oil under pressure in the lowest zone will now be prevented from flowing up since the coiled tubing packer 4 has been pressurized, thereby preventing normal through-flow, and since the presumptively zone-isolating ECP packer 5 around the casing should have a sealing function. Fig. 5 shows a pressure-controlled 8 force bringing a dose of traceable fluid 9 out
10 of its sectioned container 3 for admixture to the oil flowing from the reservoir.

The test operation described is carried out on each of the zone-isolating packers 5A, 5B, etc. in sequence from the one which is installed lowest and then one by one to the one at the top.

The lower zone-isolating packer 5A provides an adequate sealing function. Hence
15 oil will be drawn solely from the zones Z2 and Z3 above this packer. No traceable fluid 9 will be sucked round this packer into the produced oil flow 7 and on to the detector 6., which therefore indicates no leak. The test apparatus is then raised to the level of the next zone-isolating packer 5B, which does not provide a sealing
20 function. Traceable fluid 9 will be sucked round this packer into the produced oil flow 7 and on to the detector 6, which will signal both the presence of a leak and its intensity.

PATENT CLAIMS

1. A method of detecting leaks in packers round casings in oil wells
characterized by forming a seal in the well casing at the level of the packer,
injecting a tracer fluid into the well below the seal, causing oil flow from the well,
5 and monitoring the flow for the presence of tracer fluid.
2. A method according to claim 1 **characterized in that** the process is
repeated at each packer in succession up the well.
3. Apparatus for detecting leaks in packers round casings in oil wells,
characterized in that the apparatus is insertable down a well and comprises
10 packer means operable to close off the well and tracer fluid container means
operable to inject tracer fluid into the well below the packer means.
4. Apparatus according to claim 3 **characterized by** a detector located above
the packer means for detecting the tracer fluid.
5. Apparatus according to either of claims 3 and 4 **characterized in that** the
15 apparatus is carried on the end of jointless coiled tubing.
6. Apparatus according to any of claims 3 to 5 **characterized in that** the
packer means comprise a double set of cylindrically enclosing, expandable packers
(4).
7. Apparatus according to any of claims 3 to 6 **characterized in that** the
20 container means comprises a plurality of sections.

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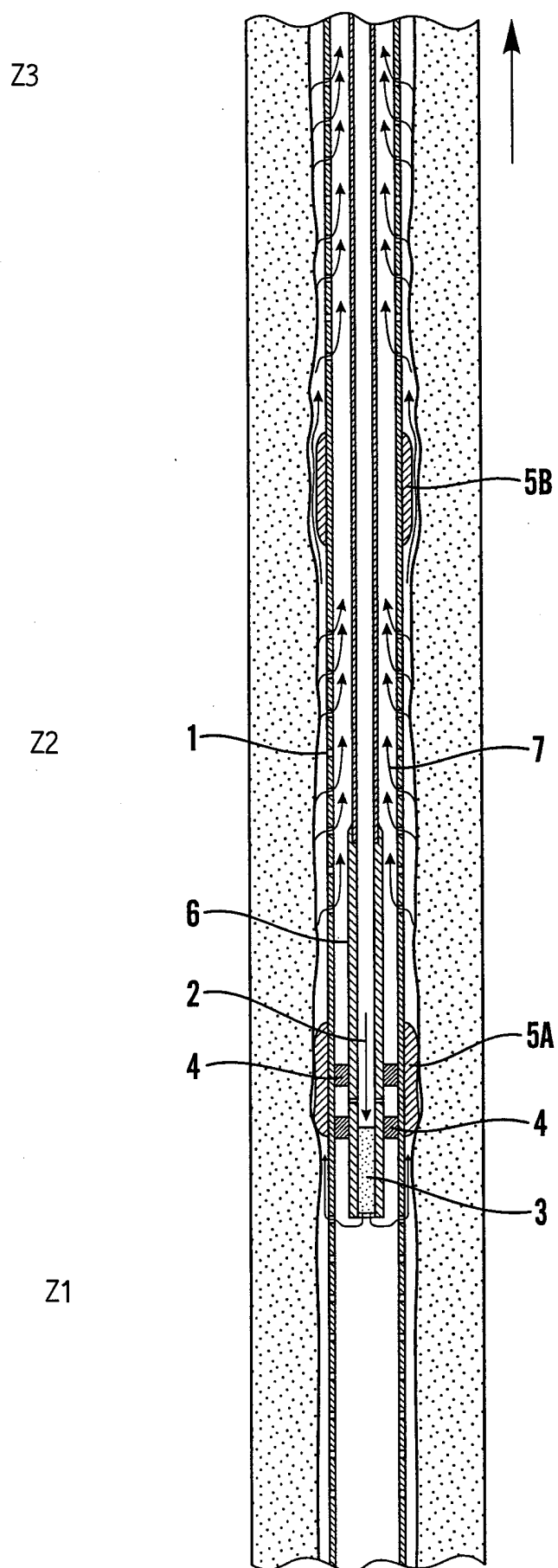
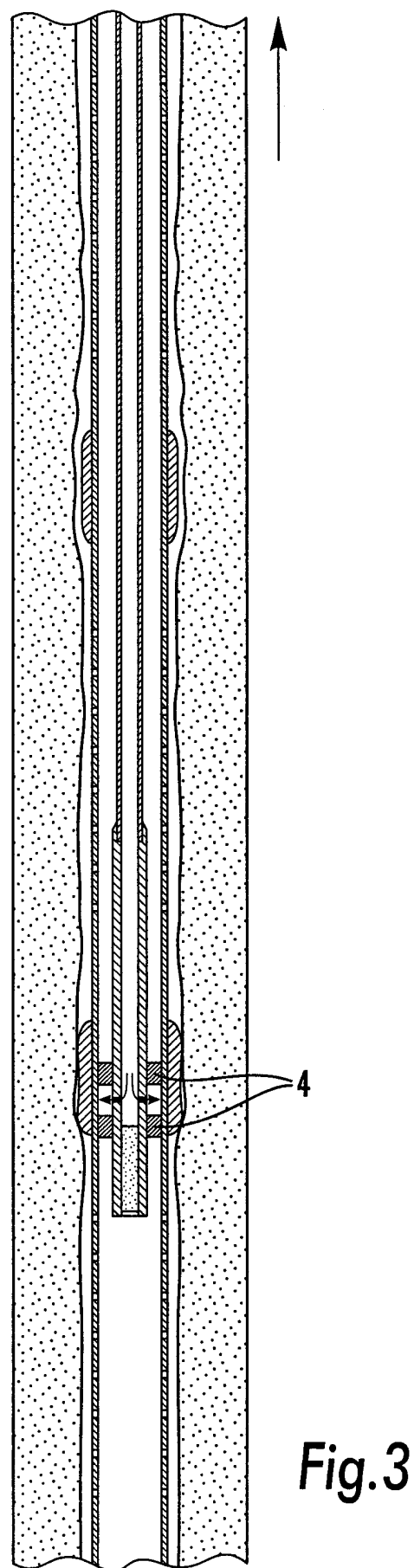
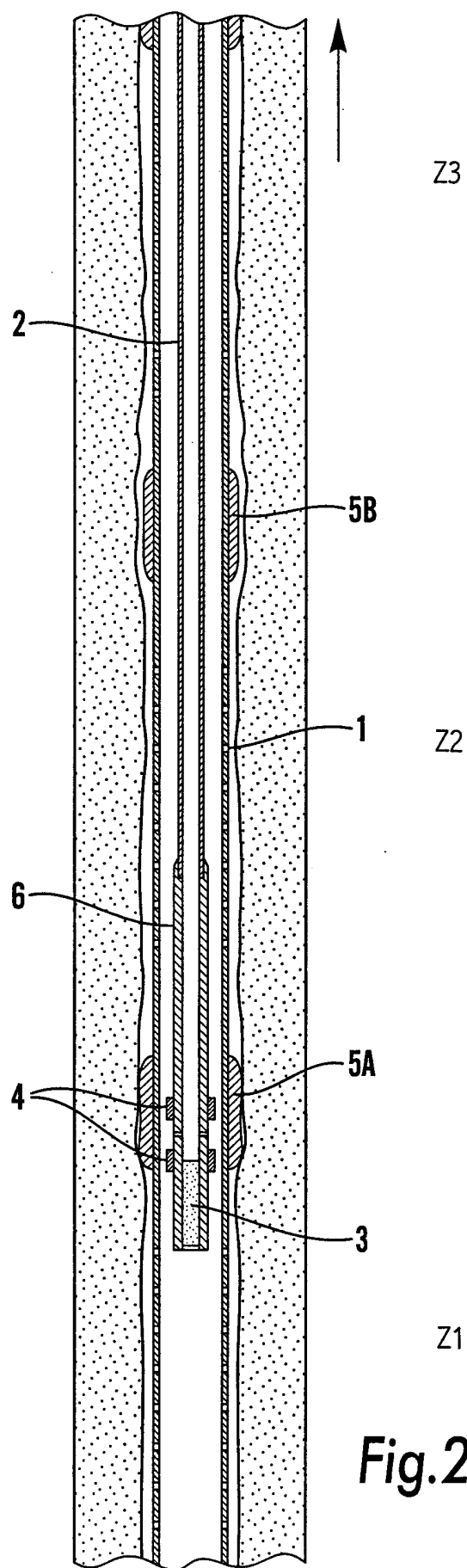
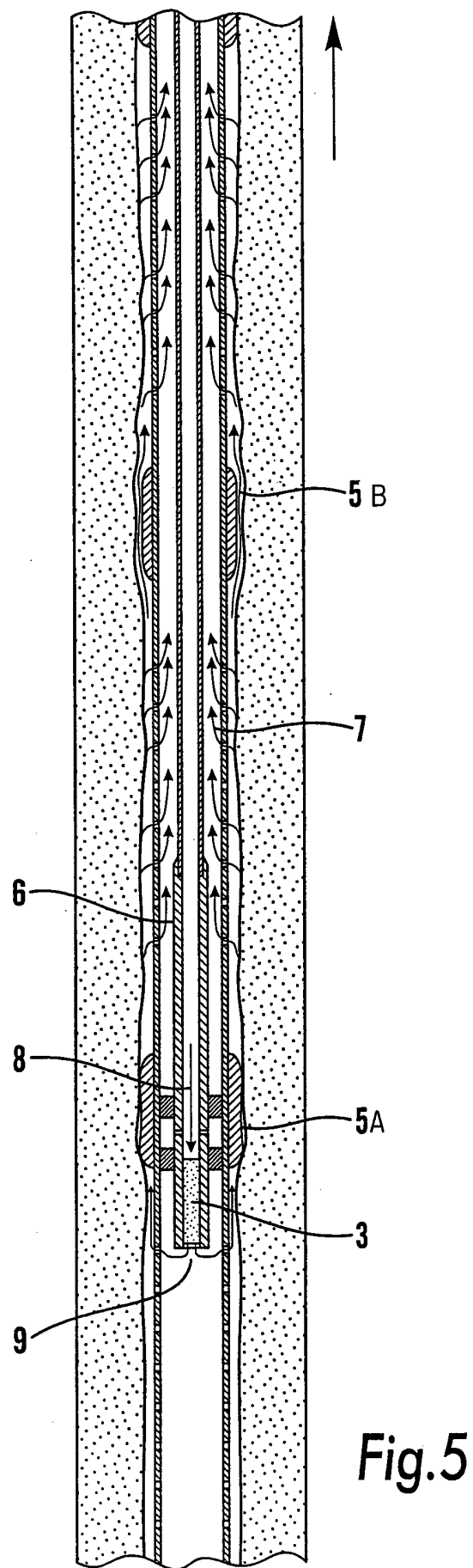
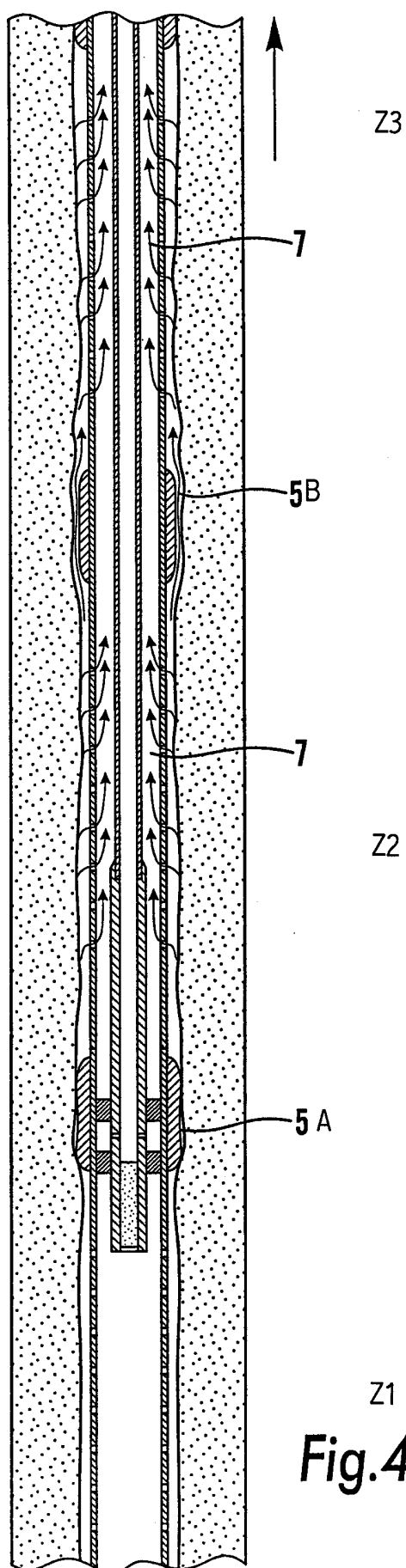


Fig. 1

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INTERNATIONAL SEARCH REPORT

International application No.

PCT/NO 00/00125

A. CLASSIFICATION OF SUBJECT MATTER

IPC7: E21B 47/10

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)

IPC7: E21B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

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EPODOC, WPI

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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A	GB 2129948 A (BOC-NOWSCO LIMITED ET AL), 23 May 1984 (23.05.84), the whole document --	1-7
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A	EP 0816631 A2 (NORSK HYDRO ASA), 7 January 1998 (07.01.98), the whole document -- -----	1-7

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