

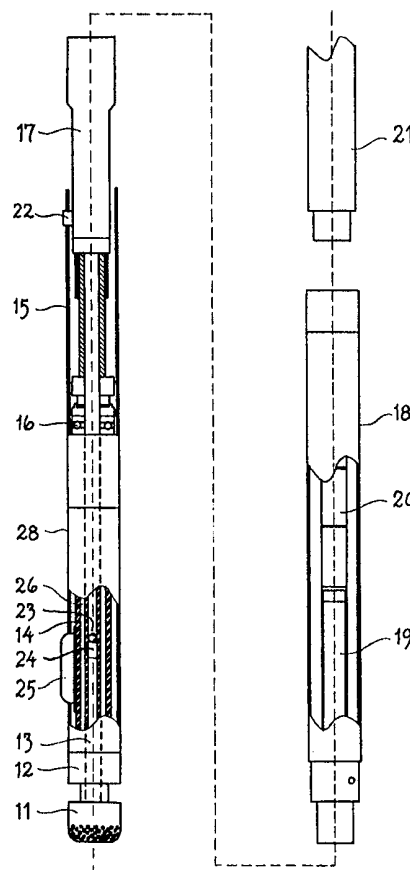
INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification ⁷ : E21B 7/04	A1	(11) International Publication Number: WO 00/34616 (43) International Publication Date: 15 June 2000 (15.06.00)
(21) International Application Number: PCT/NO99/00367 (22) International Filing Date: 7 December 1999 (07.12.99) (30) Priority Data: 19985756 9 December 1998 (09.12.98) NO (71) Applicant (for all designated States except US): DEVICO AS [NO/NO]; Varmbuveien 2, N-7224 Melhus (NO). (72) Inventor; and (75) Inventor/Applicant (for US only): TOKLE, Viktor [NO/NO]; St. Jørgensveita 9A, N-7013 Trondheim (NO). (74) Agent: CURO AS; Box 38, N-7231 Lundamo (NO).		(81) Designated States: AE, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, DE, DK, 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, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, 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> <i>In English translation (filed in Norwegian).</i>

(54) Title: APPARATUS FOR DIRECTIONAL DRILLING

(57) Abstract

Grip and guiding device for directional drilling, in order to drill straight or curved holes with a predetermined path. The device includes a drill string (11–21) comprising parts which rotate during drilling, including a drill bit (11) or a water hammer on its front end and a non-rotating packer unit (14) with a packer tubing (28) comprising one or several projecting pressure pads (25, 31–32) arranged behind the drill bit (11) or the water hammer. The pressure pad or pads are arranged to be pressed out towards the drill hole wall by means of the pressure from a drill fluid when this exceeds a certain level. The pressure pad (25) or the pressure pads (25A–25C) may be arranged asymmetrically and/or affects the packer tubing (28) asymmetrically, e.g. by having different heights. The pressure pad(s) force guiding ribs on the opposite side into the hole wall in order to prevent rotation of the packer unit (14). The pressure pad or pressure pads can on deactivation be withdrawn for performing linear drilling.



FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AL	Albania	ES	Spain	LS	Lesotho	SI	Slovenia
AM	Armenia	FI	Finland	LT	Lithuania	SK	Slovakia
AT	Austria	FR	France	LU	Luxembourg	SN	Senegal
AU	Australia	GA	Gabon	LV	Latvia	SZ	Swaziland
AZ	Azerbaijan	GB	United Kingdom	MC	Monaco	TD	Chad
BA	Bosnia and Herzegovina	GE	Georgia	MD	Republic of Moldova	TG	Togo
BB	Barbados	GH	Ghana	MG	Madagascar	TJ	Tajikistan
BE	Belgium	GN	Guinea	MK	The former Yugoslav Republic of Macedonia	TM	Turkmenistan
BF	Burkina Faso	GR	Greece	ML	Mali	TR	Turkey
BG	Bulgaria	HU	Hungary	MN	Mongolia	TT	Trinidad and Tobago
BJ	Benin	IE	Ireland	MR	Mauritania	UA	Ukraine
BR	Brazil	IL	Israel	MW	Malawi	UG	Uganda
BY	Belarus	IS	Iceland	MX	Mexico	US	United States of America
CA	Canada	IT	Italy	NE	Niger	UZ	Uzbekistan
CF	Central African Republic	JP	Japan	NL	Netherlands	VN	Viet Nam
CG	Congo	KE	Kenya	NO	Norway	YU	Yugoslavia
CH	Switzerland	KG	Kyrgyzstan	NZ	New Zealand	ZW	Zimbabwe
CI	Côte d'Ivoire	KP	Democratic People's Republic of Korea	PL	Poland		
CM	Cameroon	KR	Republic of Korea	PT	Portugal		
CN	China	KZ	Kazakhstan	RO	Romania		
CU	Cuba	LC	Saint Lucia	RU	Russian Federation		
CZ	Czech Republic	LI	Liechtenstein	SD	Sudan		
DE	Germany	LK	Sri Lanka	SE	Sweden		
DK	Denmark	LR	Liberia	SG	Singapore		
EE	Estonia						

Apparatus for directional drilling

The invention relates to a grip and guiding device for a directional drill for geotechnical drilling, especially rock drilling, more precisely a device as defined by the
5 introductory part of claim 1, particularly for directional drilling with high precision in sedimentary species of rock.

Background

A directional drill is described in NO C 168 962 which is provided with a locking
10 device or packer which is supplied with drilling fluid under pressure in order to push out locking elements or pressure pads which can be brought in contact with the bore wall and lock the directional drill relative to the wall, so that rotation of the outer tubing of the directional drill is avoided. Such pressure pads may be utilised for locking an
15 eccentric housing in a certain position or be used to bring upon the drill bit a skewed position, for thereby performing directional drilling.

From NO patent application No. 962744 is known a guidance tool for a rock drill where several pressure pads are arranged in at least two ring sections, so that the pressure pads become oriented in axial rows with projecting guiding bars oriented in a row. This solution is intended to reduce the frictional forces, which are effective in the
20 axial direction when the drill is moved forward and shall at the same time ensure a frictional force against rotation sufficient to avoid a rotational movement. The guidance is in this case ensured by a permanent eccentric housing positioned between the packer and the drill bit, known from the patent publication mentioned above.

A significant disadvantage with this known solution is that it requires several sets of
25 pressure pads in rows in the length direction of the tool. The known rock drill requires the packer in the drill hole to be positioned centrically.

Directional drills are also known with several sensor controlled pressure pads arranged symmetrically around the periphery in order to provide a so-called "modulated pretensional force". By activating the pressure pads independently is it possible to
30 obtain a deviated position of the drill bit in relation to the main axis, and thus guide the drilling to obtain a directional drilling, i.e. drilling in a predetermined curved path. This solution, however, requires a complicated sensor system and a correspondingly

complicated guidance mechanism, for the supply of pressure media to the several pressure pads. It is therefore costly and unreliable.

Objective

5 It is thus a main objective with the present invention to provide a directional drill with a grip and guidance system which is simpler than the known grip and guidance systems, and which provides a higher directional stability and higher versatility when used.

It is a particular objective to provide a directional drill which can be guided and repositioned with simpler means than the known directional drills. It is preferred to
10 make use of a versatile directional drill, which can be used, in hard rocks as well as in sedimentary species of rocks. It is preferred to be able to drill both with a core tubing with an eccentric housing and alternatively with the deviation provider in the packer area, i.e. with an active eccentric.

It is a further objective to provide a directional drill with a grip and guidance system
15 which can be used with a water hammer or another kind of drill hammer or drilling tool.

Further objectives of the invention will be disclosed by the more detailed description below.

The invention

20 The invention is defined by claim 1. Preferred embodiments of the invention are defined by the dependent claims 2-10.

The directional drill according to the invention is significantly simpler, and thereby more sturdy in use, than those previously known. This also gives the possibility to ensure a stable directional drilling by means of simple adjustment steps. Further details
25 of the invention are disclosed by the example below.

Example

In the following the invention is described in more detail with reference to the accompanying drawings, where

30 Figure 1 is a side view of a section of a directional drill according to the invention,

Figure 2a and 2b are sections of an embodiment of the invention, showing the design and position of a pressure pad and guidance ribs, with the pressure pad in an extended and retracted position respectively.

Figure 3 shows a section of fig. 2a and 2b in a larger scale, illustrating how the
5 guidance ribs are built-in,

Figure 4a-c show different side views, partly sectioned, of a part of a packer tube with three pressure pads.

Fig. 5 shows an enlarged section of fig. 4c, and

Fig. 6 shows a block diagram for a guidance system for selective activation of the
10 packer-unit.

In fig. 1 a directional drill is illustrated with a leading drill bit 11, which is connected to a drive shaft 13. A bearing housing 12, a packer unit 14 and a packer tubing 28, the back end of which is connected to an outer tubing 15, surrounds the front end of the
15 drive shaft 13.

The drive shaft 13, which is tubular, is connected to a combined locking and connecting unit 17 behind the thrust bearing 16. The combined locking and connecting unit 17 is enabled by means of a pressure valve and an orientational unit 18 connected to an electronic circuit 19 for providing information up to the surface regarding its
20 rotational angle and deviation. The orientational unit 18 also holds a battery 20. The orientational unit 18 is attached to a tube shaped drill string 21. Both the locking and connecting unit 17 and the orientational unit 18 are tube shaped and provide access for drill fluid to flow therethrough under pressure.

The locking and connecting unit 17 is equipped with a locking piston 22. An internal
25 spring member that provides a pressure P_0 presses out the locking piston 22 into an active position. At a water pressure P_1 the spring is compressed into a passive position. In order to reorient the drill, the pressure P_1 is lowered to a level P_0 , so that the spring member pushes the locking piston out. The pressure will still be high enough to expand the packer and prevent the outer tubing from rotating. By slow rotation the locking
30 piston 22 will enter a groove in the locking tube (the outer tubing 15). The sensors in the orientational unit will activate this by holding the equipment steady for a period of time whereafter a new reorientation may be performed.

The drive shaft 13 and the packer 14 are equipped with a controlling valve 23 and a draining valve 24 to be further described with reference to fig. 6. The packer unit 14 has in this example a pressure pad 25 projecting out from an opening in the packer tubing 28, the pressure pad being influenced by a packer 26 in the form of a tube shaped rubber expander as known from NO patent No. 168 962.

A preferred embodiment of the pressure pad 25 is shown in fig. 2a and 2b. Here a single pressure pad 25 is used on one side of the packer unit 14. Symmetrically to the pressure pad 25 are arranged two longitudinally oriented hard metal ribs 27A, 27B on the packer tubing 28. The ribs 27A, 27B will on activation of the packer unit 14 cut into the hole wall and prevent rotation. The configuration and position of the ribs 27A, 27B are shown in more detail in fig. 3. The pressure pad further includes two hard metal reinforcement areas 29, 30, arranged side by side in recessed grooves in the pressure pad end, so that a groove 31 is formed there between. In sedimentary species of rock this pressure pad will steer like a ski.

The pressure pad 25 can as an alternative to the hard metal reinforcement areas, comprise one or more longitudinally extending V-shaped ribs or edges to cut a groove in the hole wall and ensure a better guidance in hard rock. The size and shape of the ribs may vary dependent on the deviated material, but it will typically be V-shaped.

Fig. 2a shows the pressure pad in a projected position while in fig. 2b it is retracted.

An alternative (not illustrated) embodiment comprises two pressure pads and an oppositely, symmetrically arranged guidance rib. This solution is preferred for drilling in loose rock formations. This arrangement will give a wider extension range for the pressure pads and higher specific pressure.

A rubber packer 26 of a known design supports the pressure pad 25 internally. The pressure pad is extended and according to the example has a length 3 times its width. The dimensions are adapted to the formations in which the directional drill is to be used, and may thereby deviate from the dimensions shown. It has rounded ends to reduce the friction when moved in a forward direction.

In fig. 3 is shown a section of fig. 2A and 2B in a larger scale; depicting the recessed attachment of the guidance ribs 27A, 27B. They are attached partly recessed in longitudinally shaped grooves in a curved supporting plate 32 which is fitted into a recess in the packer tubing 28 and secured to this with one or several screws 33. The

large area of the supporting plate prevents it from penetrating deep into the mass. The advantage of this solution is that the hard metal ribs may easily be replaced for adjustment of deviation angel or for wear or breakage, without disassembling the entire directional drill.

- 5 In fig. 4a-c views are shown from three sides of a pressure element 42 with three pressure pads 25A-25C and an oppositely arranged supporting plate 32 with five attachment screws 33 and two hard metal ribs 27A, 27B.

Fig. 5 shows an enlarged section depicting the pressure pads 25A-25C and their arrangement. The pressure pads 25A-25C project from the packer tubing 28 through
10 corresponding openings 43-45.

The pressure pads are rounded at edges 46 and 47 to reduce frictional forces when moved forward. In this case each pressure pad 25A-25C is provided with respective pairs of hard metal reinforcements 29, 30 (like in fig. 2a, 2b) arranged side by side in the pressure pad, between which a guidance groove 31 is thereby formed like the groove
15 under a ski. The hard metal reinforcement may be glued or soldered to the pad.

Fig. 6 shows a block diagram of an example of a valve arrangement to control the packer unit 14. In the drive shaft 13 is arranged a filter (not shown) from which a conduit 50 leads to a first controlling valve 51 in order to control the pressure in the packer 14. With a pressure P3 the control valve 51 will close so that the packer is
20 activated.

The control valve 51 may be a standard valve which is adapted to water hydraulic systems for automatic closure when the pressure exceeds an adjustable and predetermined level. When the pressure in the drill string is reduced below the selected level, the valve is opened and the packer deactivated.

- 25 It is possible to combine this solution with an extra valve 52 which ensures that the packer does not expand before the pressure in the drill string has reach a certain level. The valve 52 is placed in the conduit to the controlling valve 51 and opens at a lower pressure than this. Between the packer 14 and the drill string there may be arranged a non-return valve 53 in order to drain the packer when the pressure in the drill string is
30 reduced.

Method of use

After pre-drilling a hole with conventional equipment, the drilling unit is entered into the hole. The locking piston 22 is locked to the outer tubing 15 during entry so that the packer unit 14 and the drive shaft 13 are attached to one another. This ensures that the orientation of the directional drill, i.e. the toolface angle (rotational position) of the packer 14 and the pressure pads are known and provides the basis for determining the further development of the drill hole.

The activation pressure for the locking piston 22 and the packer 14 can be adjusted so that the locking piston 22 is withdrawn when the pressure exceeds a certain level P1.

10 The drive shaft is thereby released from the outer tubing. It is then possible to perform a full profile drilling or a core drilling. The guidance ribs will steer the packer and prevent rotation. As soon as the packer unit has turned more than a certain angle, allowing the locking piston 22 to engage and activate the orientational unit, it will thereby initiate a reorientation of the packer unit.

15 When the pressure of the drilling fluid is increased (controlled from the surface) to a level over the activation level for the controlling valve 23, which is a higher pressure level P3, the packer becomes deactivated. Thereby the pressure pads 25 will not induce an asymmetrical positioning of the directional drill, and straight drilling can be performed. This will in this case replace directional drilling controlled by an eccentric housing. The outlet valve 51 has a constant drainage so that the packer pressure disappears when the controlling valve 23 is deactivated.

25 The invention may also be utilised together with a water hammer arranged at the front end of the packer unit, with an intermediate damper. The damper will prevent vibrations from the hammer to influence the packer to turn clockwise. In addition it will reduce the strain on the sensor elements in the orientational unit.

In order to activate such a hammer the pressure P must be increased so that the valve opens fully.

The device may comprise two or more packer units in series, where the first one is adapted to be activated to a certain eccentricity at a first pressure level, while the second and subsequent are activated to a stepwise increasing eccentricity at higher pressure levels in the drill string. Several packer units in series will increase the contacting area when drilling in sedimentary species of rock.

The invention may also be utilised for packers where the pressure pads are activated by means of two sets of jointed arms led between two central sliding casings, either by use of asymmetrical jointed arms or by use of asymmetrical pressure pads.

In an alternative embodiment, asymmetrical locking of the drill string may be
5 obtained by utilising evenly distributed pressure pads with different projections. One high and one low pressure pad may be used for example, or two low and one high. A corresponding effect may be obtained by limiting the projections to one or some pressure pads by means of adjustable stop screws.

Claims

1. Grip and guiding device for directional drilling, especially for directional drilling with high precision in the guidance of direction in order to drill straight or curved holes with predetermined paths, including a drill string (11-21) comprising parts which rotate
5 during drilling, comprising a drill bit (11) or a water hammer on its front end and a packer unit (14) with a packer tubing (28) comprising one or more pressure pads (25, 25A-25C) arranged behind the drill bit (11), wherein the pressure pad or pads are arranged to be pressed out towards the drill hole wall by means of the pressure from a drill fluid when this exceeds a certain level (P3),
10 **characterised** in that the pressure pad (25) or the pressure pads (25A-25C) is/ are arranged asymmetrically and/ or affects the packer tubing (28) asymmetrically.
2. Device according to claim 1, wherein asymmetrical pressure pads are employed, **characterised** in that one or more longitudinally extending guiding ribs (26, 27) are
15 provided to the opposite side in relation to the pressure pad or pressure pads.
3. Device according to claim 2, **characterised** in that a pressure pad (25) and two guiding ribs (26, 27) or two pressure pads and one guiding rib are arranged on a replaceable support.
20
4. Device according to any one of claims 1 and 3, **characterised** in that the pressure pad or pressure pads is/ are extended and comprise(s) several pressure pads in a row arranged on a common support.
- 25 5. Device for directional drilling according to any one of the claims 1 - 3, **characterised** in that the pressure pad or pads has/ have an evenly curved surface in the crosswise direction, with a radius dimensioned between the outer positions and are rounded off on each edge.
- 30 6. Device for directional drilling according to any one of the claims 1 - 5, **characterised** in that the locking and connecting unit (17) in a certain angular position in relation to the pressure pad or pressure pads has a radial locking piston (22) which is

influenced by the drill fluid so that it is retracted during drilling and sufficiently high hydraulic pressure, whereas reduced drill fluid pressure will allow the piston (22) to be pressed out by a spring member or the like to a locking engagement with the outer tubing (15) which is connected to the packer tubing (28).

5

7. Device according to any one of the claims 1 - 6,

characterised in that it includes a pressure valve which closes for inflow of drill fluid to the packer when the pressure of the drill fluid exceeds a certain level and the packer is provided with an outlet valve with reduced opening for draining of the pressure in the
10 packer to the drill string or the annular room in the packer.

8. Device according to claim 2,

characterised in that the eccentricity of the packer can be adjusted by changing the projection of the support for the guiding ribs.

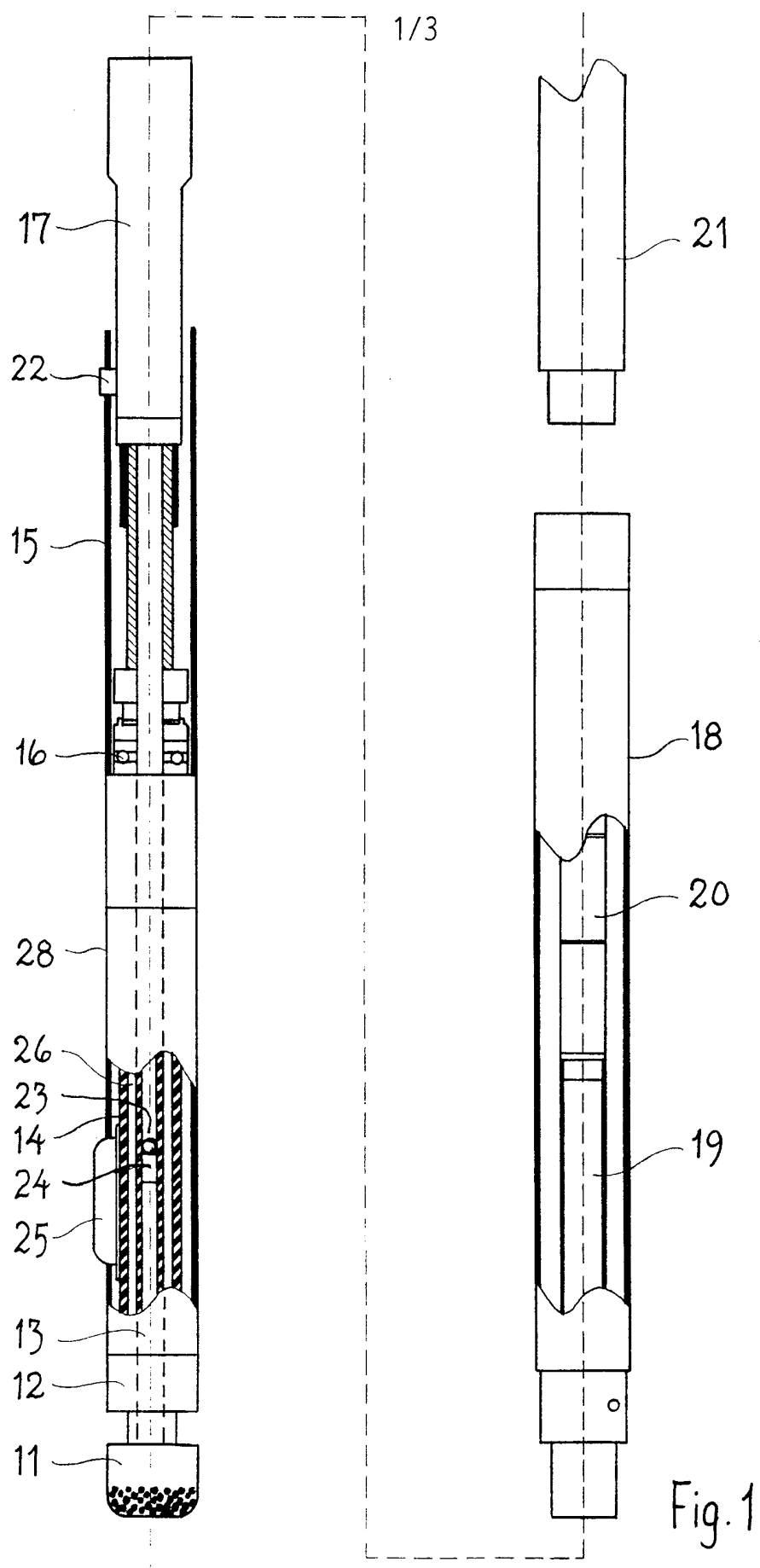
15

9. Device according to claim 1,

characterised in that the asymmetry may be obtained by allowing one or more of the pressure pads to have a height different from the other ones.

20 10. Device according to claim 9,

characterised in that the packer unit has symmetrically distributed pressure pads with asymmetrical projections, especially by means of adjustable stop screws or the use of pressure pads with different heights.



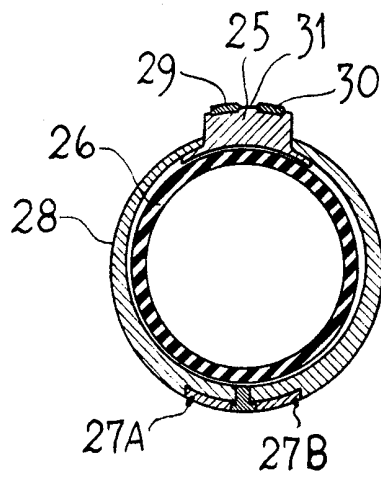


Fig. 2a

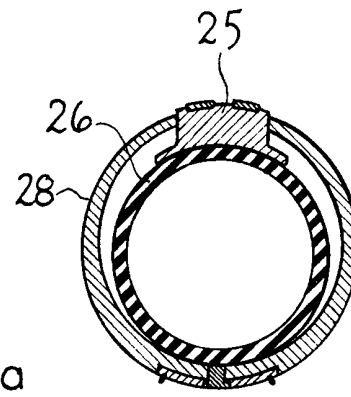


Fig. 2b

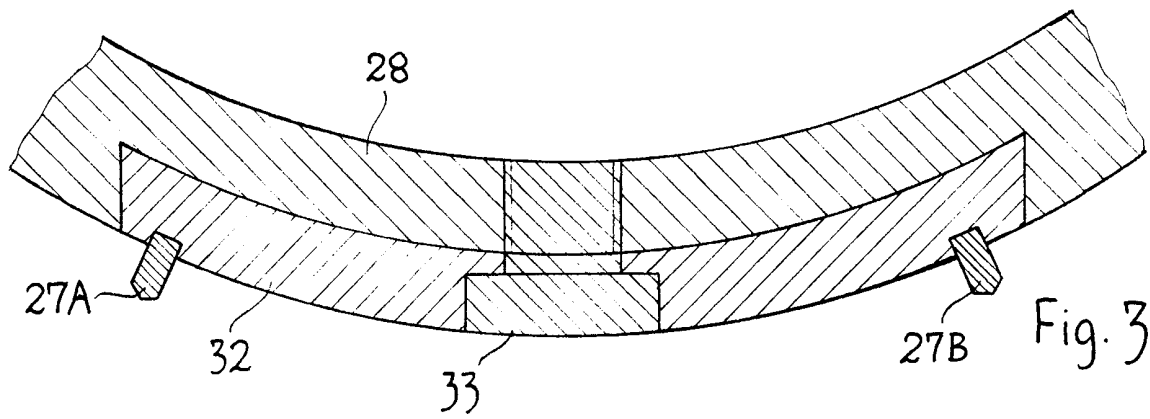


Fig. 3

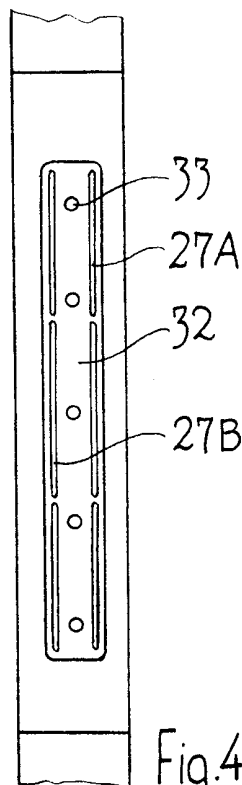


Fig. 4a

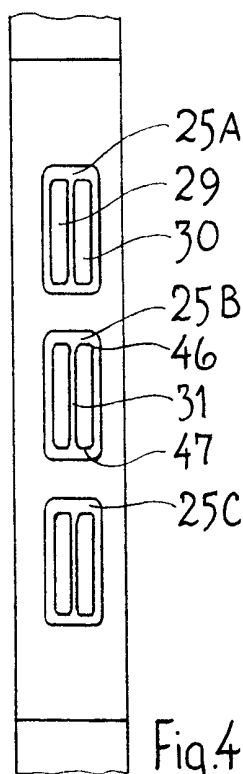


Fig. 4b

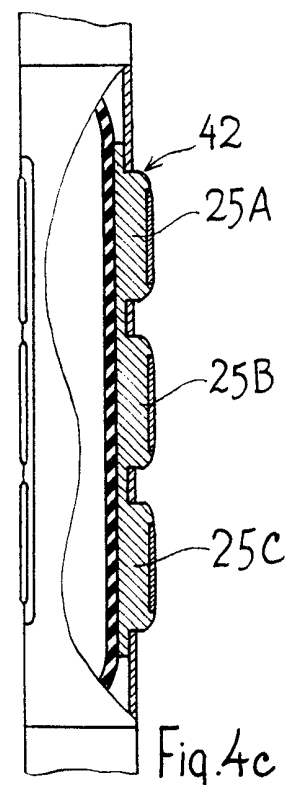
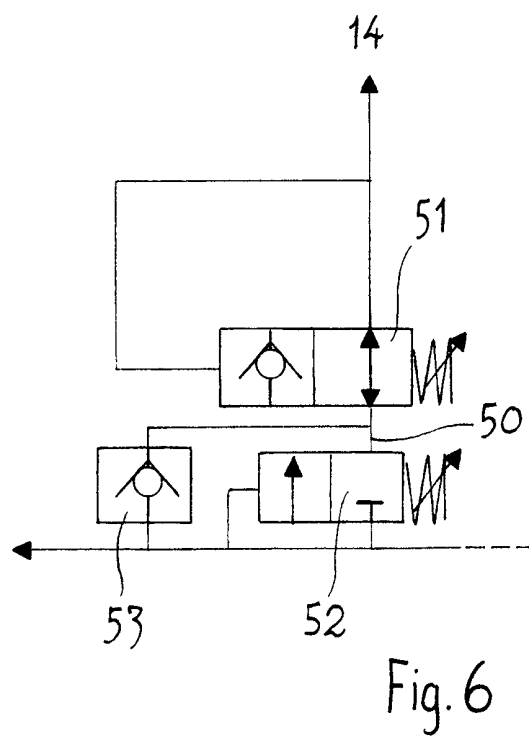
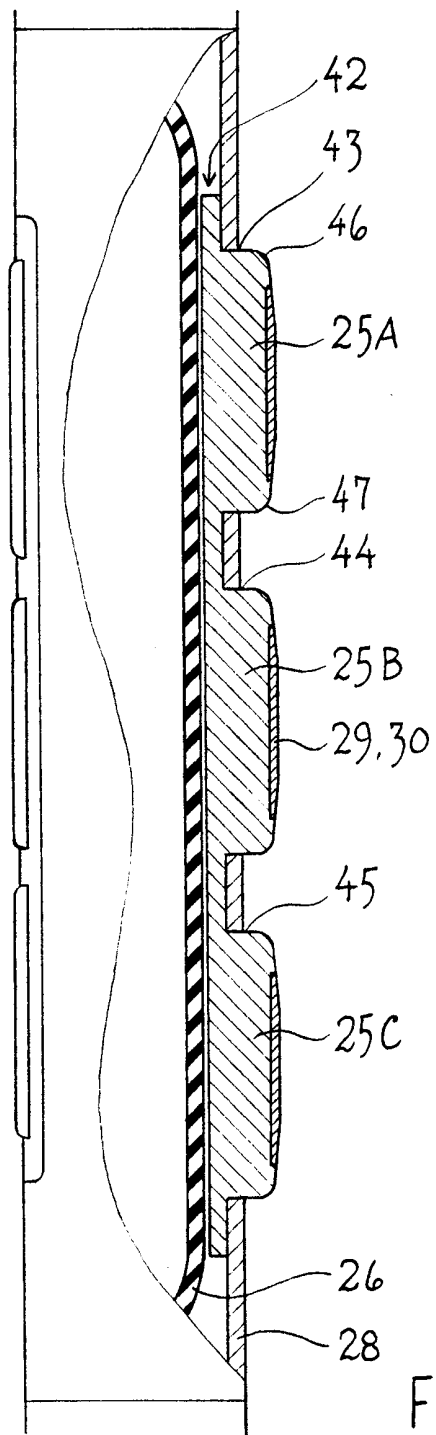


Fig. 4c

3/3



INTERNATIONAL SEARCH REPORT

International application No.

PCT/NO 99/00367

A. CLASSIFICATION OF SUBJECT MATTER

IPC7: E21B 7/04

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

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

WPI, JAPIO, EDOC

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5421421 A (R.P. APPLETON), 6 June 1995 (06.06.95), figure 1, abstract	1,4,5,7
Y	--	2
Y	US 5220963 A (B.J. PATTON), 22 June 1993 (22.06.93), column 8, line 23 - line 41, figure 5b	2
A	EP 0015137 A1 (CONOCO INC.), 3 Sept 1980 (03.09.80), figure 1, abstract	1
A	NO 168962 B (SINTEF), 13 January 1992 (13.01.92), figure 1, abstract	1



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

22 March 2000

Date of mailing of the international search report

19-04-2000

Name and mailing address of the ISA

Swedish Patent Office

Box 5055, S-102 42 STOCKHOLM

Facsimile No. +46 8 666 02 86

Authorized officer

Christer Falk / MR

Telephone No. +46 8 782 25 00

INTERNATIONAL SEARCH REPORT

International application No.

PCT/NO 99/00367

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	SE 508950 C2 (L. LIW), 16 November 1998 (16.11.98), figure 2, abstract --	1
A	US 4770258 A (T.E. FALGOUT, SR.), 13 Sept 1988 (13.09.88), figure 2, abstract --	1-2
A	DE 2609996 A1 (GURTLER, HEBERT & CO., INC.), 23 June 1977 (23.06.77), page 14, line 13 - line 31, figure 4 -- -----	1-2

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/NO 99/00367

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 5421421 A	06/06/95	AU 660431 B AU 8904991 A CA 2096849 A EP 0557379 A GB 2265648 A,B JP 6504822 T WO 9209783 A CA 2078338 A EP 0522176 A JP 6500336 T KR 9601201 B WO 9213839 A	29/06/95 25/06/92 23/05/92 01/09/93 06/10/93 02/06/94 11/06/92 31/07/92 13/01/93 13/01/94 24/01/96 20/08/92
US 5220963 A	22/06/93	US 5341886 A US 5419405 A US 5439064 A	30/08/94 30/05/95 08/08/95
EP 0015137 A1	03/09/80	AU 536113 B AU 5418479 A CA 1122965 A ZA 7907051 A	19/04/84 28/08/80 04/05/82 31/12/80
NO 168962 B	13/01/92	NONE	
SE 508950 C2	16/11/98	AU 679827 B AU 1393595 A CA 2179893 A EP 0737268 A,B SE 0737268 T3 ES 2130581 T FI 962679 A NO 305713 B NO 962744 A SE 9304322 A US 5758732 A WO 9518287 A	10/07/97 17/07/95 06/07/95 16/10/96 01/07/99 28/06/96 12/07/99 28/08/96 30/06/95 02/06/98 06/07/95
US 4770258 A	13/09/88	NONE	
DE 2609996 A1	23/06/77	CA 1062236 A DK 39776 A DK 153421 B,C GB 1510559 A IE 42243 B JP 52072301 A JP 58025839 B MY 8381 A NL 172476 B,C NL 7601543 A NO 149397 B NO 760372 A NZ 180417 A US RE29929 E US 4027734 A	11/09/79 12/06/77 11/07/88 10/05/78 02/07/80 16/06/77 30/05/83 31/12/81 05/04/83 14/06/77 02/01/84 14/06/77 28/04/78 13/03/79 07/06/77