

(19) World Intellectual Property Organization
International Bureau



(43) International Publication Date
31 January 2008 (31.01.2008)

PCT

(10) International Publication Number
WO 2008/013458 A1

(51) International Patent Classification:
E21B 7/08 (2006.01)

(21) International Application Number:
PCT/NO2007/000268

(22) International Filing Date: 12 July 2007 (12.07.2007)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
20063402 24 July 2006 (24.07.2006) NO

(71) Applicant (for all designated States except US): SIRA-KVINA KRAFTSELSKAP DA [NO/NO]; P.O. Box 38, N-4441 Tonstad (NO).

(72) Inventors; and

(75) Inventors/Applicants (for US only): HAUGHOM, Sigurd, Kjell [NO/NO]; Sigbjørn K. Tonstad veg 28, N-4440 Tonstad (NO). KNUTSEN, Kjell [NO/NO]; Mydland, N-4440 Tonstad (NO).

(74) Agent: HÅMSØ PATENTBYRÅ ANS; P.O. Box 171, N-4302 Sandnes (NO).

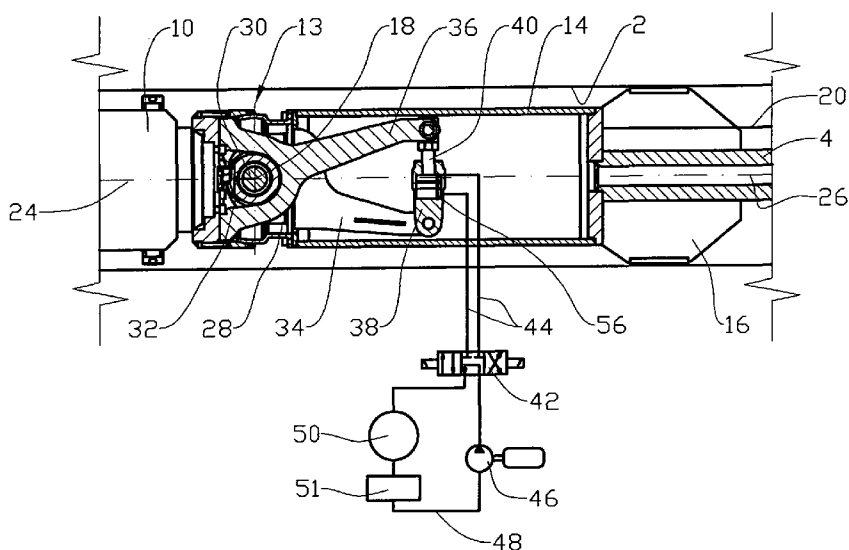
(81) Designated States (unless otherwise indicated, for every kind of national protection available): AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RS, RU, SC, SD, SE, SG, SK, SL, SM, SV, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States (unless otherwise indicated, for every kind of regional protection available): ARIPO (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IS, IT, LT, LU, LV, MC, MT, NL, PL, PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:
— with international search report

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(54) Title: A METHOD AND A DEVICE FOR DIRECTIONAL CONTROL OF A ROCK DRILLING MACHINE



(57) Abstract: A method for the directional control of a rock-drilling machine, the drilling unit (1) of the rock-drilling machine, which is located in a borehole (2), comprising at least a pi-lot drill bit (6) or an underreamer drill bit (8), the drill bit(s) (6, 8) being driven by an electric motor (10) via a gearbox (12), and the drill bit(s) (6, 8) being moved into the rock (3) by means of a feeding rod (4) extending from a feeding machine at the outside the borehole (2), and the drill bit(s) (6, 8), gearbox (12) and motor (10) being pivoted in a controlled manner about a steering axis (18) which is approximately perpendicular to the center axis (26) of the feeding rod (4).

WO 2008/013458 A1

A METHOD AND A DEVICE FOR DIRECTIONAL CONTROL OF A ROCK
DRILLING MACHINE

This invention relates to a method for controlling a rock-
drilling machine. More particularly, it relates to a method
5 for the directional control of a rock-drilling machine, in
which the drilling unit of the rock-drilling machine, which
is located in a borehole, includes at least a pilot drill bit
or an underreamer drill bit, and in which the drill bits are
driven by an electric motor via a gearbox near the drill
10 bits. The drill bits are moved into the rock by means of a
feeding rod extending from a feeding machine at the outside
of the borehole, the drill bits, gearbox and motor being
pivoted in a controlled manner about a steering axis which is
approximately perpendicular to the longitudinal axis of the
15 feeding rod. The invention also includes a device for
practising the method.

In rock drilling in which the borehole has too small a cross-
section for persons to be in the borehole, it is known to use
a rock-drilling machine which is provided with one pilot
20 drill bit and at least one underreamer drill bit located
behind the pilot drill bit relative to the direction of
drilling.

Further, it is known to place a drive motor at the drill
bits, the drill bits and motor being fed into the borehole by

means of a feeding rod extending from a feeding machine located outside the borehole.

Rock-drilling machines of this kind are controlled directionally by the axis of rotation of the drill bit being given a fixed angle relative to the longitudinal axis of the feeding rod. This causes the drill bits to drill at an angle relative to the feeding rod. The desired direction of drilling is achieved by rotating the feeding rod about the centre axis of the borehole until the drill bits drill in the desired direction.

The method has the effect of the borehole exhibiting a partially considerable helical shape, which makes further movement of the drill bits into the borehole difficult, especially when relatively long boreholes are involved. The helical shape can also make subsequent further underreaming of the borehole difficult.

The invention has for its object to remedy or reduce at least one of the drawbacks of the prior art.

The object is achieved in accordance with the invention through the features, which are specified in the description below and in the claims that follow.

The directional control of a rock-drilling machine in accordance with the invention, in which the drilling unit of the rock-drilling machine is in a borehole, including at least a pilot drill bit or an underreamer drill bit, the drill bits being driven by an electric motor via a gearbox, and the drill bits being moved into the rock by means of a feeding rod extending from a feeding machine at the outside of the borehole, is characterized by the drill bits, gearbox and motor being pivoted in a controlled manner about a

steering axis which is approximately perpendicular to the centre axis of the feeding rod.

The position of the drilling unit is monitored by a control system, the rotational angle of the drilling unit about the centre axis of the feeding rod and the steering angle between the drill bits and the feeding rod being adjusted in accordance with the desired value. Otherwise the feeding rod does not rotate beyond the springing rotation caused by the torque of the drill bits.

The steering axis is located between the drill bit and a support at the inner end portion of the feeding rod, the drilling unit being provided with a steering joint including a steering axle. The centre axis of the steering axle coincides with the steering axis.

The steering joint typically includes an axle mount, which is connected to the feeding rod via an intermediate housing, and a bearing housing which is connected to the motor.

An actuator is connected between the axle mount and the bearing housing and is arranged to pivot the bearing housing about the steering axle and relative to the axle mount. The actuator is supplied with pressurized fluid from a circulation pump via a control valve.

The control valve is controlled by the control system on the basis of the measured position of the drilling unit.

The angle α between the centre axis of the drill bit and the centre axis of the feeding rod is monitored by means of a transmitter.

In what follows is described a non-limiting example of a preferred method and embodiment which are visualized in the

accompanying drawings, in which:

Figure 1 shows the drilling unit of a rock-drilling machine during drilling in a borehole, the centre axis of the drill bit having been pivoted into an angle relative to the centre axis of the feeding rod, a control device being indicated schematically;

Figure 2 shows, on a larger scale and partially in section, the steering axle and actuator of the drilling unit, the control valve and hydraulic circuit being shown schematically; and

Figure 3 shows the same as figure 2, but here the actuator piston has been displaced.

In the drawings the reference numeral 1 indicates a drilling unit of a rock-drilling machine not shown in its entirety.

The drilling unit 1 is located in a borehole 2 in the rock 3 and is connected by means of a feeding rod 4 to a feeding machine, not shown, located outside the borehole 2.

The drilling unit 1 includes a pilot drill bit 6 and an underreamer drill bit 8 which is located somewhat behind the pilot drill bit 6. The drill bits 6 and 8 are driven by an electric motor 10 via a gearbox 12.

The motor 10 is connected, together with the gearbox 12 and drill bits 6 and 8, to a steering joint 13 connected in turn to an intermediate housing 14. At its opposite end portion the intermediate housing 14 is fixedly connected to a support 16 and to the inner end portion of the feeding rod 4. The drilling unit 1 bears on the borehole 2 by the drill bits 6, 8 and by the support 16. The pivot axis of the steering joint 13 forms a steering axis 18.

A power and control cable 20 extends along the borehole 2 from a control system 22 located outside the borehole 2 in to the drilling unit 1.

In figure 1 the centre axis 24 of the drill bits 6 and 8 has been given an angle α relative to the centre axis 26 of the feeding rod 4.

The steering joint 13 is connected to the intermediate housing 14 by means of an axle mount 28, see figure 2, supporting a steering axle 30. The centre axis of the steering axle 30 coincides with the steering axis 18.

A bearing housing 32, which is bearingly rotatable about the steering axle 30, is connected to the motor 10. The axle mount 28, steering axle 30 and bearing housing 32 form the steering joint 13. The torque of the motor 10 is transmitted via the steering joint 13, intermediate housing 14 and feeding rod 4 to the feeding machine not shown.

A counter arm 34, which is connected to the axle mount 28, projects somewhat into the intermediate housing 14.

Correspondingly, a steering arm 36 connected to the bearing housing 32 also projects somewhat into the intermediate housing 14. An actuator 38, here in the form of a hydraulic cylinder, is connected between the free end portions of the counter arm 34 and the steering arm 36.

Movement of the piston rod 40 of the actuator 38 causes the steering arm 36 together with the bearing housing 32, motor 10, gearbox 12 and drill bits 6 and 8 to be pivoted about the steering axis 18, so that the angle α between the centre axis 24 of the drill bits 6, 8 and the centre axis 26 of the feeding rod 4 changes, see figure 3.

The actuator 38 is connected to a control valve 42 by means

of pipe connections 44. The coupling is shown schematically in figure 2. The control valve 42 is supplied with pressurized fluid from a circulation pump 46 via circulation pipes 48. The circulation pump 46 normally circulates fluid to the support of the drill bits 6, 8, indicated here 5 schematically by the reference numeral 50, via a tank 51.

The control valve 42 is controlled and the circulation pump 46 is supplied with energy by means of wires, not shown, via the power and control cable 20.

10 The control system 22 includes a control cabinet 52 with necessary components and a control console 54. From the control console 54 the position, power consumption and operating temperature, for example, of the rock-drilling machine may be monitored in a manner known *per se*.

15 When it is indicated that the direction of drilling of the drilling unit 1 should be adjusted, the feeding rod 4 is rotated, if necessary, about its centre axis 26 until the steering axis 18 takes the desired direction. The control valve 42 is activated so that the piston rod 40 is moved in 20 the actuator 38 until the angle α takes the desired value, which is fed back from a transmitter 56 at the actuator 38.

The circulation pump 46 and control valve 42 is disposed in the intermediate housing 14. The intermediate housing 14 may form a fluid reservoir for pressurized fluid.

25 Flushing water for cleaning the drill bits 6, 8 is supplied via the feeding rod 4, flowing via conduit elements, not shown, through the intermediate housing 14, steering joint 13, motor 10, gearbox 12 up to the drill bits 6, 8.

C l a i m s

1. A method for directional control of a rock-drilling machine, the drilling unit (1) of the rock-drilling machine, which is located in a borehole (2),
5 comprising at least a pilot drill bit (6) or an underreamer drill bit (8), the drill bit(s) (6, 8) being driven by an electric motor (10) via a gearbox (12), and the drill bit(s) (6, 8) being moved into the rock (3) by means of a feeding rod (4) extending from
10 a feeding machine outside the borehole (2), c h a - r a c t e r i z e d i n t h a t t h e d r i l l b i t (s) (6 , 8) , g e a r b o x (1 2) a n d m o t o r (1 0) a r e p i v o t e d i n a c o n t r o l l e d m a n n e r a b o u t a s t e e r i n g a x i s (1 8) w h i c h i s a p p r o x i m a t e l y p e r p e n d i c u l a r t o t h e c e n t r e a x i s (2 6) o f t h e f e e d i n g r o d (4) .
15
2. The method in accordance with claim 1, c h a r a c - t e r i z e d i n t h a t t h e p o s i t i o n o f t h e d r i l l i n g u n i t (1) i s m o n i t o r e d b y a c o n t r o l s y s t e m (2 2) , a f t e r w h i c h t h e r o t a t i o n a l a n g l e o f t h e d r i l l i n g u n i t (1)
20 a b o u t t h e c e n t r e a x i s (2 6) o f t h e f e e d i n g r o d (4) a n d a n a n g l e (α) b e t w e e n t h e c e n t r e a x i s (2 4) o f t h e d r i l l b i t (6 , 8) a n d t h e c e n t r e a x i s (2 6) o f t h e f e e d i n g r o d (4) i s a d j u s t e d i n a c c o r d a n c e w i t h t h e d e s i r e d v a l u e .
3. A control device for a rock-drilling machine, the
25 d r i l l i n g u n i t (1) o f t h e r o c k - d r i l l i n g m a c h i n e , w h i c h i s l o c a t e d i n a b o r e h o l e (2) , c o m p r i s i n g a t l e a s t a p i l o t d r i l l b i t (6) o r a n u n d e r r e a m e r d r i l l b i t (8) , t h e d r i l l b i t (s) (6 , 8) b e i n g d r i v e n b y a n e l e c t r i c m o t o r (1 0) v i a a g e a r b o x (1 2) , a n d t h e d r i l l b i t (s)
30 (6 , 8) b e i n g m o v e d i n t o t h e r o c k (3) b y m e a n s o f a f e e d i n g r o d (4) e x t e n d i n g f r o m a f e e d i n g m a c h i n e a t t h e o u t s i d e o f t h e b o r e h o l e (2) , c h a r a c t e r i -

z e d i n t h a t t h e d r i l l b i t (s) (6 , 8) , t h e g e a r b o x (1 2) a n d t h e m o t o r (1 0) a r e p i v o t a b l e a b o u t a s t e e r i n g a x i s (1 8) w h i c h i s a p p r o x i m a t e l y p e r p e n d i c u l a r t o t h e c e n t r e a x i s (2 6) o f t h e f e e d i n g r o d (4) .

- 5 4. The device in accordance with claim 3, c h a r a c -
t e r i z e d i n t h a t t h e s t e e r i n g a x i s (1 8) i s
l o c a t e d b e t w e e n t h e d r i l l b i t (6 , 8) a n d a s u p p o r t
(1 6) a t t h e i n n e r e n d p o r t i o n o f t h e f e e d i n g r o d (4) .
- 10 5. The device in accordance with claim 3, c h a r a c -
t e r i z e d i n t h a t t h e d r i l l i n g u n i t (1) i s
p r o v i d e d w i t h a s t e e r i n g j o i n t (1 3) c o m p r i s i n g a
s t e e r i n g a x l e (3 0) , t h e c e n t r e a x i s o f t h e s t e e r i n g
a x l e (3 0) c o i n c i d i n g w i t h t h e s t e e r i n g a x i s (1 8) .
- 15 6. The device in accordance with claim 5, c h a r a c -
t e r i z e d i n t h a t t h e s t e e r i n g j o i n t (1 3) i s
c o n n e c t e d t o a n i n t e r m e d i a t e h o u s i n g (1 4) c o n n e c t e d t o
t h e f e e d i n g r o d (4) b y m e a n s o f a n a x l e m o u n t (2 8) a n d
t o t h e m o t o r (1 0) b y m e a n s o f a b e a r i n g h o u s i n g (3 2) .
- 20 7. The device in accordance with claim 6, c h a r a c -
t e r i z e d i n t h a t a n a c t u a t o r (3 8) i s
c o n n e c t e d b e t w e e n t h e a x l e m o u n t (2 8) a n d t h e b e a r i n g
h o u s i n g (3 2) a n d a r r a n g e d t o p i v o t t h e b e a r i n g h o u s i n g
(3 2) r e l a t i v e t o t h e a x l e m o u n t (2 8) a b o u t t h e
s t e e r i n g a x l e (3 0) .
- 25 8. The device in accordance with claim 7, c h a r a c -
t e r i z e d i n t h a t t h e a c t u a t o r (3 8) i s
s u p p l i e d w i t h p r e s s u r i z e d f l u i d f r o m a c i r c u l a t i o n
p u m p (4 6) v i a a c o n t r o l v a l v e (4 2) .
- 30 9. The device in accordance with claim 8, c h a r a c -
t e r i z e d i n t h a t t h e c o n t r o l v a l v e (4 2) i s

controlled by a control system (22) on the basis of the measured position of the drilling unit (1).

- 5 10. The device in accordance with claim 9, characterized in that an angle (α) between the centre axis (24) of the drill bit (6, 8) and the centre axis (26) of the feeding rod (4) is monitored by means of a transmitter (56).

1/3

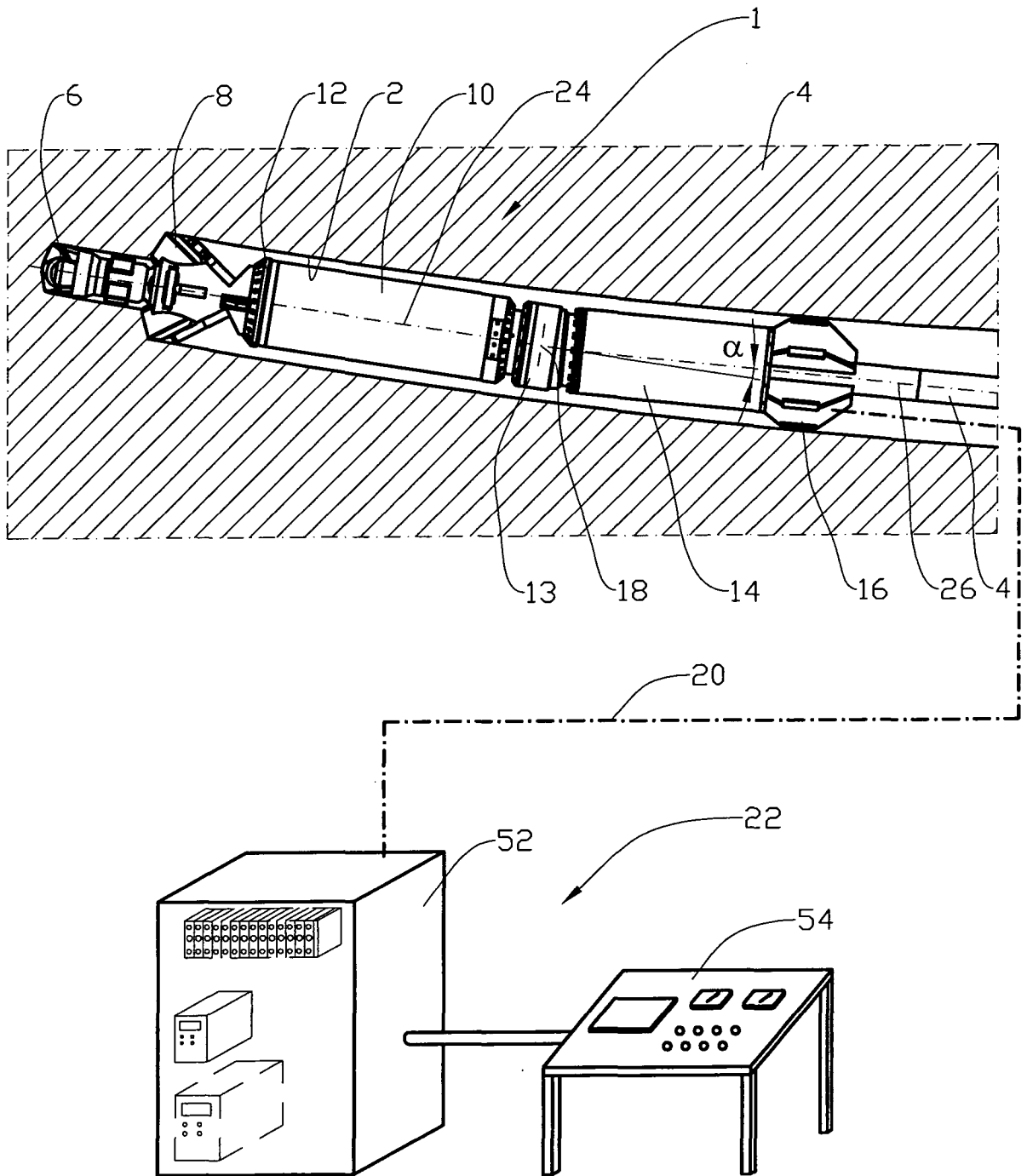


Fig. 1

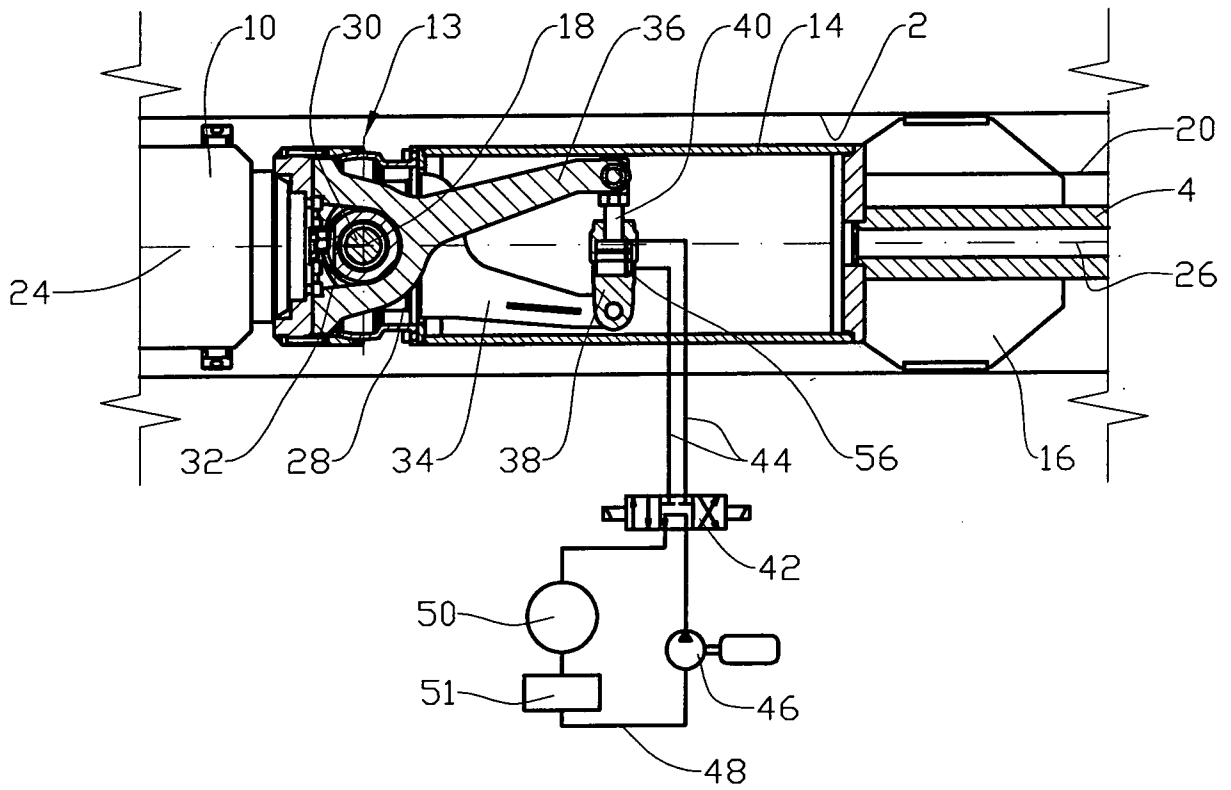


Fig. 2

3/3

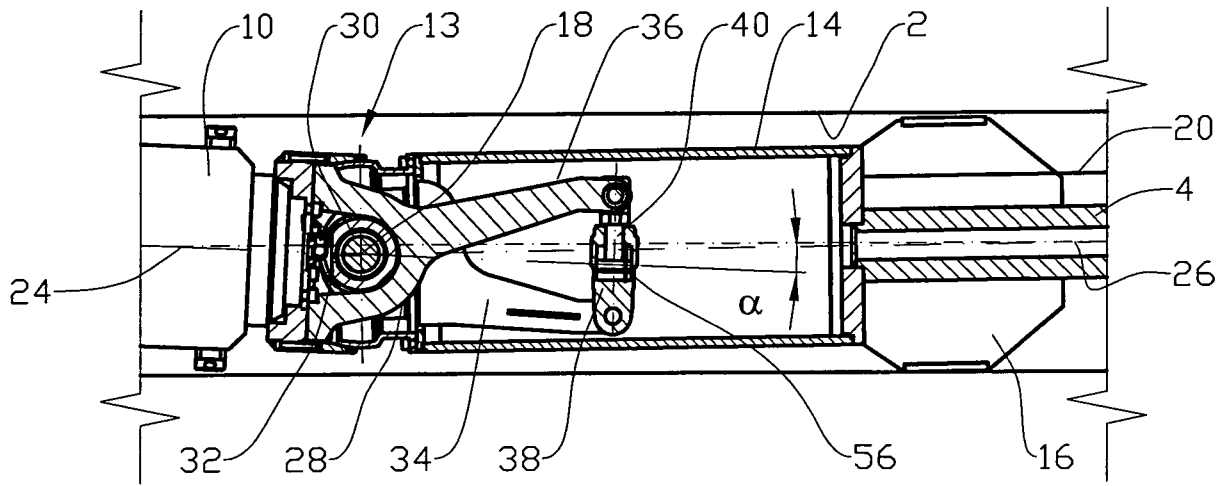


Fig. 3

INTERNATIONAL SEARCH REPORT

International application No.

PCT/NO2007/000268

A. CLASSIFICATION OF SUBJECT MATTER

IPC: see extra sheet

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)

IPC: 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)

EPO-INTERNAL, WPI DATA, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 20040026128 A1 (V. KRUEGER ET AL), 12 February 2004 (12.02.2004), paragraph (0010) ----- -----	1-10

 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 application or patent 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

31 October 2007

Date of mailing of the international search report

05-11-2007

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

Björn Lindkvist / MRo
Telephone No. +46 8 782 25 00

International patent classification (IPC)**E21B 7/08** (2006.01)**Download your patent documents at www.prv.se**

The cited patent documents can be downloaded at www.prv.se by following the links:

- In English/Searches and advisory services/Cited documents (service in English) or
- e-tjänster/anförda dokument (service in Swedish).

Use the application number as username.

The password is **SYZOSVWJIK**.

Paper copies can be ordered at a cost of 50 SEK per copy from PRV InterPat (telephone number 08-782 28 85).

Cited literature, if any, will be enclosed in paper form.

INTERNATIONAL SEARCH REPORT
Information on patent family members

01/09/2007

International application No.

PCT/NO2007/000268

US	20040026128	A1	12/02/2004	CA	2279338	A,C	06/08/1998
				DE	69801646	D,T	04/07/2002
				EP	0954674	A,B	10/11/1999
				NO	993697	A	28/09/1999
				US	6609579	B	26/08/2003
				US	6626254	B	30/09/2003
				US	7028789	B	18/04/2006
				US	20020088648	A	11/07/2002
				US	20060254825	A	16/11/2006
				WO	9834003	A	06/08/1998
