UNITED STATES PATENT AND TRADEMARK OFFICE

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APPLICATION NO.	ISSUE DATE	PATENT NO.	ATTORNEY DOCKET NO.	CONFIRMATION NO.
14/692,484	08/14/2018	10047581	36362.0150U2-	3851

23859 7590 07/25/2018

Ballard Spahr LLP
SUITE 1000
999 PEACHTREE STREET
ATLANTA, GA 30309-3915

ISSUE NOTIFICATION

The projected patent number and issue date are specified above.

Determination of Patent Term Adjustment under 35 U.S.C. 154 (b)
(application filed on or after May 29, 2000)

The Patent Term Adjustment is 377 day(s). Any patent to issue from the above-identified application will include an indication of the adjustment on the front page.

If a Continued Prosecution Application (CPA) was filed in the above-identified application, the filing date that determines Patent Term Adjustment is the filing date of the most recent CPA.

Applicant will be able to obtain more detailed information by accessing the Patent Application Information Retrieval (PAIR) WEB site (http://pair.uspto.gov).

Any questions regarding the Patent Term Extension or Adjustment determination should be directed to the Office of Patent Legal Administration at (571)-272-7702. Questions relating to issue and publication fee payments should be directed to the Application Assistance Unit (AAU) of the Office of Data Management (ODM) at (571)-272-4200.

APPLICANT(s) (Please see PAIR WEB site http://pair.uspto.gov for additional applicants):

CHRISTOPHER L. DRENTH, Ontario, CANADA;
LONGYEAR TM, INC., South Jordan, UT;
GORDON STEWART, Claremont, AUSTRALIA;
GLOBALTECH CORPORATION PTY LTD, CANNING VALE, AUSTRALIA;
KHALED HEJLEH, Peppermint Grove, AUSTRALIA;

The United States represents the largest, most dynamic marketplace in the world and is an unparalleled location for business investment, innovation, and commercialization of new technologies. The USA offers tremendous resources and advantages for those who invest and manufacture goods here. Through SelectUSA, our nation works to encourage and facilitate business investment. To learn more about why the USA is the best country in the world to develop technology, manufacture products, and grow your business, visit SelectUSA.gov.

Document Description: Issue Fee Payment (PTO-85B)

Issue Fee Transmittal Form

Application Number	Filing Date	First Named Inventor	Atty. Docket No.	Confirmation No.
14692484	21-Apr-2015	CHRISTOPHER DRENTH	36362.0150U2-	3851

TITLE OF INVENTION :

CORE BARREL HEAD ASSEMBLY WITH AN INTEGRATED SAMPLE ORIENTATION TOOL AND SYSTEM FOR USING SAME

Entity Status	Application Type	Art Unit	Class - Subclass	EXAMINER
Regular Undiscounted	Utility under 35 USC 111(a)	3676	044000	MICHAEL WILLS III

Issue Fee Due	Publication Due	Total Fee(s) Due	Date Due	Prev. Paid Fee
$1000	$0	$1000	12-Jul-2018	$0

1.Change of Correspondence Address and/or Indication Of Fee Address (37 CFR 1.33 & 1.363)

Current Correspondence Address:	Current Indicated Fee Address :
23859 Ballard Spahr LLP SUITE 1000 999 PEACHTREE STREET ATLANTA GA 30309-3915 UNITED STATES 678-420-9300 USpatentmail@ballardspahr.com	
☐ Change of correspondence address requested, system generated AIA/122-EFS form attached	☐ Fee Address indication requested, system generated SB/47-EFS form attached

2.Entity Status

Change in Entity Status

○ Applicant certifying micro entity status; system generated Micro Entity certification form attached. See 37 CFR 1.29.
Note: Absent a valid certification of micro entity status, issue fee payment in the micro entity amount will not be accepted at the risk of application abandonment. If this box is checked, you will be prompted to choose a micro entity status on the gross income basis (37 CFR 1.29(a)) or the institution of higher education basis (37 CFR 1.29(d)), and make the applicable certification online.

○ Applicant asserting small entity status. See 37 CFR 1.27.
Note: If the application was previously under micro entity status, checking this box will be taken to be a notification of loss of entitlement to micro entity status.

◉ Applicant changing to regular undiscounted fee status.
Note: Checking this box will be taken to be a notification of loss of entitlement to small or micro entity status, as applicable.

Doc Code: IFEE PTOL/85B-EFS

Document Description: Issue Fee Payment (PTO-85B)

3.The Following Fee(s) Are Submitted:

☒ Issue Fee	☐ I authorize USPTO to apply my previously paid issue fee to the current fees due
☐ Publication Fee	☐ The Director is hereby authorized to apply my previously paid issue fee to the current fee due and to charge deficient fees to Deposit Account Number _____
☐ Advance Order - # of copies _____	☒ If **in addition to** the payment of the issue fee amount submitted with this form, there are any discrepancies in any amount(s) due, the Director is authorized to charge any deficiency, or credit any overpayment, to Deposit Account Number 140629 . The **issue fee must be submitted** with this form. **If payment of the issue fee does not accompany this form, checking this box and providing a deposit account number will NOT be effective to satisfy full payment of the fee(s) due.**

4.Firm and/or Attorney Names To Be Printed

NOTE: If no name is listed, no name will be printed
For printing on the patent front page, list to be displayed as entered

1. BALLARD SPAHR LLP
2.
3.

5.Assignee Name(s) and Residence Data To Be Printed

PLEASE NOTE: Unless an assignee is identified below, no assignee data will appear on the patent. If an assignee is identified below, the document has been filed for recordation as set forth in 37 CFR 3.11. Completion of this form is NOT a substitute for filing an assignment.

Name	City	State	Country	Category
LONGYEAR TM, INC.	Salt Lake City	UTAH	united states	corporation
GLOBALTECH CORPORATION PTY LTD	Canning Vale		australia	corporation

6.Signature

I certify, in accordance with 37 CFR 1.4(d)(4) that I am an attorney or agent registered to practice before the Patent and Trademark Office who has filed and has been granted power of attorney in this application. I also certify that this Fee(s) Transmittal form is being transmitted to the USPTO via EFS-WEB on the date indicated below.

Signature	/Joseph P. Anderson, III/	**Date**	07-11-2018
Name	Joseph P. Anderson	**Registration Number**	59245

Electronic Patent Application Fee Transmittal

Application Number:	14692484
Filing Date:	21-Apr-2015
Title of Invention:	CORE BARREL HEAD ASSEMBLY WITH AN INTEGRATED SAMPLE ORIENTATION TOOL AND SYSTEM FOR USING SAME
First Named Inventor/Applicant Name:	CHRISTOPHER L. DRENTH
Filer:	Joseph P. Anderson
Attorney Docket Number:	36362.0150U2-

Filed as Large Entity

Filing Fees for Utility under 35 USC 111(a)

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
UTILITY APPL ISSUE FEE	1501	1	1000	1000
PUBL. FEE- EARLY, VOLUNTARY, OR NORMAL	1504	1	0	0
Pages:				
Claims:				
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Post-Allowance-and-Post-Issuance:				
Extension-of-Time:				
Miscellaneous:				
		Total in USD ($)		**1000**

Electronic Acknowledgement Receipt

EFS ID:	33146188
Application Number:	14692484
International Application Number:	
Confirmation Number:	3851
Title of Invention:	CORE BARREL HEAD ASSEMBLY WITH AN INTEGRATED SAMPLE ORIENTATION TOOL AND SYSTEM FOR USING SAME
First Named Inventor/Applicant Name:	CHRISTOPHER L. DRENTH
Customer Number:	23859
Filer:	Joseph P. Anderson
Filer Authorized By:	
Attorney Docket Number:	36362.0150U2-
Receipt Date:	11-JUL-2018
Filing Date:	21-APR-2015
Time Stamp:	12:40:22
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment Type	CARD
Payment was successfully received in RAM	$1000
RAM confirmation Number	071118INTEFSW12401902
Deposit Account	
Authorized User	
The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows:	

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Issue Fee Payment (PTO-85B)	Web85b.pdf	48748 93d2a4e4ad396c30c902b790d72637574136afbe	no	3
Warnings:					
Information:					
2	Fee Worksheet (SB06)	fee-info.pdf	31965 3ec81a1681bc82bb76bd0d93a45a2a93fd589913	no	2
Warnings:					
Information:					
		Total Files Size (in bytes):	80713		

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111
If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.
National Stage of an International Application under 35 U.S.C. 371
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.
New International Application Filed with the USPTO as a Receiving Office
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

Document Description: Issue Fee Payment (PTO-85B)

Issue Fee Transmittal Form

Application Number	Filing Date	First Named Inventor	Atty. Docket No.	Confirmation No.
14692484	21-Apr-2015	CHRISTOPHER DRENTH	36362.0150U2-	3851

TITLE OF INVENTION :

CORE BARREL HEAD ASSEMBLY WITH AN INTEGRATED SAMPLE ORIENTATION TOOL AND SYSTEM FOR USING SAME

Entity Status	Application Type	Art Unit	Class - Subclass	EXAMINER
Regular Undiscounted	Utility under 35 USC 111(a)	3676	044000	MICHAEL WILLS III

Issue Fee Due	Publication Due	Total Fee(s) Due	Date Due	Prev. Paid Fee
$1000	$0	$1000	12-Jul-2018	$0

1.Change of Correspondence Address and/or Indication Of Fee Address (37 CFR 1.33 & 1.363)

Current Correspondence Address:	Current Indicated Fee Address :
23859 Ballard Spahr LLP SUITE 1000 999 PEACHTREE STREET ATLANTA GA 30309-3915 UNITED STATES 678-420-9300 USpatentmail@ballardspahr.com	
☐ Change of correspondence address requested, system generated AIA/122-EFS form attached	☐ Fee Address indication requested, system generated SB/47-EFS form attached

2.Entity Status

Change in Entity Status

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◉ Applicant changing to regular undiscounted fee status.
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Doc Code: IFEE PTOL/85B-EFS

Document Description: Issue Fee Payment (PTO-85B)

3.The Following Fee(s) Are Submitted:

☒ Issue Fee	☐ I authorize USPTO to apply my previously paid issue fee to the current fees due
☐ Publication Fee	☐ The Director is hereby authorized to apply my previously paid issue fee to the current fee due and to charge deficient fees to Deposit Account Number _____
☐ Advance Order - # of copies _____	☒ If **in addition to** the payment of the issue fee amount submitted with this form, there are any discrepancies in any amount(s) due, the Director is authorized to charge any deficiency, or credit any overpayment, to Deposit Account Number 140629 . The **issue fee must be submitted** with this form. **If payment of the issue fee does not accompany this form, checking this box and providing a deposit account number will NOT be effective to satisfy full payment of the fee(s) due.**

4.Firm and/or Attorney Names To Be Printed

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For printing on the patent front page, list to be displayed as entered

1. BALLARD SPAHR LLP
2.
3.

5.Assignee Name(s) and Residence Data To Be Printed

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Name	City	State	Country	Category
LONGYEAR TM, INC.	Salt Lake City	UTAH	united states	corporation
GLOBALTECH CORPORATION PTY LTD	Canning Vale		australia	corporation

6.Signature

I certify, in accordance with 37 CFR 1.4(d)(4) that I am an attorney or agent registered to practice before the Patent and Trademark Office who has filed and has been granted power of attorney in this application. I also certify that this Fee(s) Transmittal form is being transmitted to the USPTO via EFS-WEB on the date indicated below.

Signature	/Joseph P. Anderson, III/	**Date**	07-10-2018
Name	Joseph P. Anderson	**Registration Number**	59245

Electronic Acknowledgement Receipt	
EFS ID:	33136742
Application Number:	14692484
International Application Number:	
Confirmation Number:	3851
Title of Invention:	CORE BARREL HEAD ASSEMBLY WITH AN INTEGRATED SAMPLE ORIENTATION TOOL AND SYSTEM FOR USING SAME
First Named Inventor/Applicant Name:	CHRISTOPHER L. DRENTH
Customer Number:	23859
Filer:	Joseph P. Anderson
Filer Authorized By:	
Attorney Docket Number:	36362.0150U2-
Receipt Date:	10-JUL-2018
Filing Date:	21-APR-2015
Time Stamp:	15:13:18
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment Type	CARD
Payment was successfully received in RAM	$160
RAM confirmation Number	071118INTEFSW14530800
Deposit Account	
Authorized User	
The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows:	

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Issue Fee Payment (PTO-85B)	Web85b.pdf	48691 9d3db2f6ea489cc62638c2e8215fa6ae635e84cc	no	3
Warnings:					
Information:					
		Total Files Size (in bytes):	48691		

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111
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National Stage of an International Application under 35 U.S.C. 371
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.
New International Application Filed with the USPTO as a Receiving Office
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

NOTICE OF ALLOWANCE AND FEE(S) DUE

23859 7590 04/12/2018

Ballard Spahr LLP
SUITE 1000
999 PEACHTREE STREET
ATLANTA, GEORGIA 30309-3915
UNITED STATES OF AMERICA

EXAMINER
WILLS III, MICHAEL R

ART UNIT	PAPER NUMBER
3676	

DATE MAILED: 04/12/2018

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
14/692,484	04/21/2015	CHRISTOPHER L. DRENTH	36362.0150U2-	3851

TITLE OF INVENTION: CORE BARREL HEAD ASSEMBLY WITH AN INTEGRATED SAMPLE ORIENTATION TOOL AND SYSTEM FOR USING SAME

APPLN. TYPE	ENTITY STATUS	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
REGULAR	UNDISCOUNTED	$1000	$0.00	$0.00	$1000	07/12/2018

THE APPLICATION IDENTIFIED ABOVE HAS BEEN EXAMINED AND IS ALLOWED FOR ISSUANCE AS A PATENT. PROSECUTION ON THE MERITS IS CLOSED. THIS NOTICE OF ALLOWANCE IS NOT A GRANT OF PATENT RIGHTS. THIS APPLICATION IS SUBJECT TO WITHDRAWAL FROM ISSUE AT THE INITIATIVE OF THE OFFICE OR UPON PETITION BY THE APPLICANT. SEE 37 CFR 1.313 AND MPEP 1308.

THE ISSUE FEE AND PUBLICATION FEE (IF REQUIRED) MUST BE PAID WITHIN THREE MONTHS FROM THE MAILING DATE OF THIS NOTICE OR THIS APPLICATION SHALL BE REGARDED AS ABANDONED. THIS STATUTORY PERIOD CANNOT BE EXTENDED. SEE 35 U.S.C. 151. THE ISSUE FEE DUE INDICATED ABOVE DOES NOT REFLECT A CREDIT FOR ANY PREVIOUSLY PAID ISSUE FEE IN THIS APPLICATION. IF AN ISSUE FEE HAS PREVIOUSLY BEEN PAID IN THIS APPLICATION (AS SHOWN ABOVE), THE RETURN OF PART B OF THIS FORM WILL BE CONSIDERED A REQUEST TO REAPPLY THE PREVIOUSLY PAID ISSUE FEE TOWARD THE ISSUE FEE NOW DUE.

HOW TO REPLY TO THIS NOTICE:

I. Review the ENTITY STATUS shown above. If the ENTITY STATUS is shown as SMALL or MICRO, verify whether entitlement to that entity status still applies.

If the ENTITY STATUS is the same as shown above, pay the TOTAL FEE(S) DUE shown above.

If the ENTITY STATUS is changed from that shown above, on PART B - FEE(S) TRANSMITTAL, complete section number 5 titled "Change in Entity Status (from status indicated above)".

For purposes of this notice, small entity fees are 1/2 the amount of undiscounted fees, and micro entity fees are 1/2 the amount of small entity fees.

II. PART B - FEE(S) TRANSMITTAL, or its equivalent, must be completed and returned to the United States Patent and Trademark Office (USPTO) with your ISSUE FEE and PUBLICATION FEE (if required). If you are charging the fee(s) to your deposit account, section "4b" of Part B - Fee(s) Transmittal should be completed and an extra copy of the form should be submitted. If an equivalent of Part B is filed, a request to reapply a previously paid issue fee must be clearly made, and delays in processing may occur due to the difficulty in recognizing the paper as an equivalent of Part B.

III. All communications regarding this application must give the application number. Please direct all communications prior to issuance to Mail Stop ISSUE FEE unless advised to the contrary.

IMPORTANT REMINDER: Utility patents issuing on applications filed on or after Dec. 12, 1980 may require payment of maintenance fees. It is patentee's responsibility to ensure timely payment of maintenance fees when due.

PTOL-85 (Rev. 02/11)

PART B - FEE(S) TRANSMITTAL

Complete and send this form, together with applicable fee(s), to: Mail **Mail Stop ISSUE FEE**
Commissioner for Patents
P.O. Box 1450
Alexandria, Virginia 22313-1450
or Fax (571)-273-2885

INSTRUCTIONS: This form should be used for transmitting the ISSUE FEE and PUBLICATION FEE (if required). Blocks 1 through 5 should be completed where appropriate. All further correspondence including the Patent, advance orders and notification of maintenance fees will be mailed to the current correspondence address as indicated unless corrected below or directed otherwise in Block 1, by (a) specifying a new correspondence address; and/or (b) indicating a separate "FEE ADDRESS" for maintenance fee notifications.

CURRENT CORRESPONDENCE ADDRESS (Note: Use Block 1 for any change of address)

23859 7590 04/12/2018
Ballard Spahr LLP
SUITE 1000
999 PEACHTREE STREET
ATLANTA, GEORGIA 30309-3915
UNITED STATES OF AMERICA

Note: A certificate of mailing can only be used for domestic mailings of the Fee(s) Transmittal. This certificate cannot be used for any other accompanying papers. Each additional paper, such as an assignment or formal drawing, must have its own certificate of mailing or transmission.

Certificate of Mailing or Transmission
I hereby certify that this Fee(s) Transmittal is being deposited with the United States Postal Service with sufficient postage for first class mail in an envelope addressed to the Mail Stop ISSUE FEE address above, or being facsimile transmitted to the USPTO (571) 273-2885, on the date indicated below.

(Depositor's name)
(Signature)
(Date)

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
14/692,484	04/21/2015	CHRISTOPHER L. DRENTH	36362.0150U2-	3851

TITLE OF INVENTION: CORE BARREL HEAD ASSEMBLY WITH AN INTEGRATED SAMPLE ORIENTATION TOOL AND SYSTEM FOR USING SAME

APPLN. TYPE	ENTITY STATUS	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
REGULAR	UNDISCOUNTED	$1000	$0.00	$0.00	$1000	07/12/2018

EXAMINER	ART UNIT	CLASS-SUBCLASS
WILLS III, MICHAEL R	3676	175-044000

1. Change of correspondence address or indication of "Fee Address" (37 CFR 1.363).

❑ Change of correspondence address (or Change of Correspondence Address form PTO/SB/122) attached.

❑ "Fee Address" indication (or "Fee Address" Indication form PTO/SB/47; Rev 03-02 or more recent) attached. **Use of a Customer Number is required.**

2. For printing on the patent front page, list
(1) The names of up to 3 registered patent attorneys or agents OR, alternatively,
(2) The name of a single firm (having as a member a registered attorney or agent) and the names of up to 2 registered patent attorneys or agents. If no name is listed, no name will be printed.

1 _____
2 _____
3 _____

3. ASSIGNEE NAME AND RESIDENCE DATA TO BE PRINTED ON THE PATENT (print or type)

PLEASE NOTE: Unless an assignee is identified below, no assignee data will appear on the patent. If an assignee is identified below, the document has been filed for recordation as set forth in 37 CFR 3.11. Completion of this form is NOT a substitute for filing an assignment.

(A) NAME OF ASSIGNEE (B) RESIDENCE: (CITY and STATE OR COUNTRY)

Please check the appropriate assignee category or categories (will not be printed on the patent) : ❑ Individual ❑ Corporation or other private group entity ❑ Government

4a. The following fee(s) are submitted:

❑ Issue Fee

❑ Publication Fee (No small entity discount permitted)

❑ Advance Order - # of Copies _____

4b. Payment of Fee(s): **(Please first reapply any previously paid issue fee shown above)**

❑ A check is enclosed.

❑ Payment by credit card. Form PTO-2038 is attached.

❑ The director is hereby authorized to charge the required fee(s), any deficiency, or credits any overpayment, to Deposit Account Number _____ (enclose an extra copy of this form).

5. **Change in Entity Status** (from status indicated above)

❑ Applicant certifying micro entity status. See 37 CFR 1.29

❑ Applicant asserting small entity status. See 37 CFR 1.27

❑ Applicant changing to regular undiscounted fee status.

NOTE: Absent a valid certification of Micro Entity Status (see forms PTO/SB/15A and 15B), issue fee payment in the micro entity amount will not be accepted at the risk of application abandonment.
NOTE: If the application was previously under micro entity status, checking this box will be taken to be a notification of loss of entitlement to micro entity status.
NOTE: Checking this box will be taken to be a notification of loss of entitlement to small or micro entity status, as applicable.

NOTE: This form must be signed in accordance with 37 CFR 1.31 and 1.33. See 37 CFR 1.4 for signature requirements and certifications.

Authorized Signature _____ Date _____

Typed or printed name _____ Registration No. _____

PTOL-85 Part B (10-13) Approved for use through 10/31/2013. OMB 0651-0033 U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

Ex.2001 / IPR2023-00642 / Page 15 of 870
Reflex USA LLC v. Longyear TM, Inc. and Globaltech Corporation Pty Ltd.

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
14/692,484	04/21/2015	CHRISTOPHER L. DRENTH	36362.0150U2-	3851

23859 7590 04/12/2018

Ballard Spahr LLP
SUITE 1000
999 PEACHTREE STREET
ATLANTA, GEORGIA 30309-3915
UNITED STATES OF AMERICA

EXAMINER	
WILLS III, MICHAEL R	

ART UNIT	PAPER NUMBER
3676	

DATE MAILED: 04/12/2018

PTOL-85 (Rev. 02/11)

OMB Clearance and PRA Burden Statement for PTOL-85 Part B

The Paperwork Reduction Act (PRA) of 1995 requires Federal agencies to obtain Office of Management and Budget approval before requesting most types of information from the public. When OMB approves an agency request to collect information from the public, OMB (i) provides a valid OMB Control Number and expiration date for the agency to display on the instrument that will be used to collect the information and (ii) requires the agency to inform the public about the OMB Control Number's legal significance in accordance with 5 CFR 1320.5(b).

The information collected by PTOL-85 Part B is required by 37 CFR 1.311. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, Virginia 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, Virginia 22313-1450. Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

Privacy Act Statement

The Privacy Act of 1974 (P.L. 93-579) requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether disclosure of these records is required by the Freedom of Information Act.
2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.
3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.
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5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.
6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).
7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.
8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspection or an issued patent.
9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

Notice of Allowability	Application No. 14/692,484	Applicant(s) DRENTH et al.	
	Examiner MICHAEL R WILLS III	Art Unit 3676	AIA Status Yes

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address--

All claims being allowable, PROSECUTION ON THE MERITS IS (OR REMAINS) CLOSED in this application. If not included herewith (or previously mailed), a Notice of Allowance (PTOL-85) or other appropriate communication will be mailed in due course. **THIS NOTICE OF ALLOWABILITY IS NOT A GRANT OF PATENT RIGHTS.** This application is subject to withdrawal from issue at the initiative of the Office or upon petition by the applicant. See 37 CFR 1.313 and MPEP 1308.

1. ☑ This communication is responsive to RCE filed January 24, 2018.
   ☐ A declaration(s)/affidavit(s) under **37 CFR 1.130(b)** was/were filed on _____.

2. ☐ An election was made by the applicant in response to a restriction requirement set forth during the interview on _____; the restriction requirement and election have been incorporated into this action.

3. ☑ The allowed claim(s) is/are 1,6-7 and 10-39 . As a result of the allowed claim(s), you may be eligible to benefit from the **Patent Prosecution Highway** program at a participating intellectual property office for the corresponding application. For more information , please see **http://www.uspto.gov/patents/init_events/pph/index.jsp** or send an inquiry to **PPHfeedback@uspto.gov.**

4. ☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

   Certified copies:

   a) ☐ All b) ☐ Some *c) ☐ None of the:

   1. ☐ Certified copies of the priority documents have been received.
   2. ☐ Certified copies of the priority documents have been received in Application No. _____ .
   3. ☐ Copies of the certified copies of the priority documents have been received in this national stage application from the International Bureau (PCT Rule 17.2(a)).

   * Certified copies not received: _____ .

Applicant has THREE MONTHS FROM THE "MAILING DATE" of this communication to file areply complying with the requirements noted below. Failure to timely comply will result in ABANDONMENT of this application.
THIS THREE-MONTH PERIOD IS NOT EXTENDABLE.

5. ☐ CORRECTED DRAWINGS (as "replacement sheets") must be submitted.
   ☐ including changes required by the attached Examiner's Amendment / Comment or in the Office action of Paper No./Mail Date _____ .

   Identifying indicia such as the application number (see 37 CFR 1.84(c)) should be written on the drawings in the front (not the back) of each sheet. Replacement sheet(s) should be labeled as such in the header according to 37 CFR 1.121(d).

6. ☐ DEPOSIT OF and/or INFORMATION about the deposit of BIOLOGICAL MATERIAL must be submitted. Note the attached Examiner's comment regarding REQUIREMENT FOR THE DEPOSIT OF BIOLOGICAL MATERIAL.

Attachment(s)

1. ☐ Notice of References Cited (PTO-892)
2. ☑ Information Disclosure Statements (PTO/SB/08), Paper No./Mail Date _____.
3. ☐ Examiner's Comment Regarding Requirement for Deposit of Biological Material _____.
4. ☐ Interview Summary (PTO-413), Paper No./Mail Date. _____.
5. ☐ Examiner's Amendment/Comment
6. ☐ Examiner's Statement of Reasons for Allowance
7. ☑ Other Reasons for crossing out IDS filed January 24, 2018.

/MICHAEL R WILLS III/
Primary Examiner, Art Unit 3676

Notice of Pre-AIA or AIA Status

1. The present application, filed on or after March 16, 2013, is being examined under the first inventor to file provisions of the AIA.

Information Disclosure Statement

2. The information disclosure statement (IDS) filed January 24, 2018 fails to comply with the provisions of 37 CFR 1.97, 1.98 and MPEP § 609 because the references cited were previous included in the IDS filed January 17, 2018. Since the references are a duplicate, they will not be considered. It has been placed in the application file, but the information referred to therein has not been considered as to the merits. Applicant is advised that the date of any re-submission of any item of information contained in this information disclosure statement or the submission of any missing element(s) will be the date of submission for purposes of determining compliance with the requirements based on the time of filing the statement, including all certification requirements for statements under 37 CFR 1.97(e). See MPEP § 609.05(a).

Conclusion

3. Any inquiry concerning this communication or earlier communications from the examiner should be directed to MICHAEL R WILLS III whose telephone number is (571)272-5521. The examiner can normally be reached on Monday-Friday 8:30am to 5:00pm.

Examiner interviews are available via telephone, in-person, and video conferencing using a USPTO supplied web-based collaboration tool. To schedule an interview, applicant is encouraged to use the USPTO Automated Interview Request (AIR) at http://www.uspto.gov/interviewpractice.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Waseem Moorad can be reached on 5712703436. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

/MICHAEL R WILLS III/
Primary Examiner, Art Unit 3676

Issue Classification	Application/Control No.	Applicant(s)/Patent Under Reexamination
	14/692,484	DRENTH et al.
	Examiner	**Art Unit**
	MICHAEL R WILLS III	3676

CPC							
Symbol						**Type**	**Version**
E21B	/	25	/	16		F	2013-01-01

CPC Combination Sets								
Symbol						**Type**	**Set**	**Ranking**	**Version**
	/		/						

NONE		Total Claims Allowed:	
(Assistant Examiner)	(Date)	33	
/MICHAEL R WILLS III/ Primary Examiner, Art Unit 3676	17 February 2018	O.G. Print Claim(s)	O.G. Print Figure
(Primary Examiner)	(Date)	1	1

U.S. Patent and Trademark Office — Part of Paper No.: 20180217

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Reflex USA LLC v. Longyear TM, Inc. and Globaltech Corporation Pty Ltd.

Issue Classification	Application/Control No.	Applicant(s)/Patent Under Reexamination
	14/692,484	DRENTH et al.
	Examiner	**Art Unit**
	MICHAEL R WILLS III	3676

INTERNATIONAL CLASSIFICATION				
CLAIMED				
E21B	/	25	/	16

NON-CLAIMED				
	/		/	

US ORIGINAL CLASSIFICATION	
CLASS	**SUBCLASS**

CROSS REFERENCES(S)						
CLASS	**SUBCLASS (ONE SUBCLASS PER BLOCK)**					

NONE		**Total Claims Allowed:**	
(Assistant Examiner)	(Date)	33	
/MICHAEL R WILLS III/ Primary Examiner, Art Unit 3676	17 February 2018	O.G. Print Claim(s)	O.G. Print Figure
(Primary Examiner)	(Date)	1	1

U.S. Patent and Trademark Office — Part of Paper No.: 20180217

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Reflex USA LLC v. Longyear TM, Inc. and Globaltech Corporation Pty Ltd.

Issue Classification	Application/Control No.	Applicant(s)/Patent Under Reexamination
	14/692,484	DRENTH et al.
	Examiner	**Art Unit**
	MICHAEL R WILLS III	3676

☐ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47

CLAIMS

Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original
1	1	10	16	19	25	28	34								
2	6	11	17	20	26	29	35								
3	7	12	18	21	27	30	36								
4	10	13	19	22	28	31	37								
5	11	14	20	23	29	32	38								
6	12	15	21	24	30	33	39								
7	13	16	22	25	31										
8	14	17	23	26	32										
9	15	18	24	27	33										

NONE		**Total Claims Allowed:**	
(Assistant Examiner)	(Date)	33	
/MICHAEL R WILLS III/ Primary Examiner, Art Unit 3676	17 February 2018	O.G. Print Claim(s)	O.G. Print Figure
(Primary Examiner)	(Date)	1	1

U.S. Patent and Trademark Office — Part of Paper No.: 20180217

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Reflex USA LLC v. Longyear TM, Inc. and Globaltech Corporation Pty Ltd.

Search Notes	Application/Control No.	Applicant(s)/Patent Under Reexamination
	14/692,484	DRENTH et al.
	Examiner	Art Unit
	MICHAEL R WILLS III	3676

CPC - Searched*		
Symbol	Date	Examiner
E21B25/16	8/12/17	MW

CPC Combination Sets - Searched*		
Symbol	Date	Examiner

US Classification - Searched*			
Class	Subclass	Date	Examiner

* See search history printout included with this form or the SEARCH NOTES box below to determine the scope of the search.

Search Notes		
Search Notes	Date	Examiner
Invetor Name Search	8/12/17	MW
Forward/Backward Search	8/12/17	MW
See East Search History	8/12/17	MW
texted searched classes E21B17/028, E21B47/09	8/12/17	MW
Updated Search	10/30/2017	MW
Updated Search	02/17/2018	MW

Interference Search			
US Class/CPC Symbol	US Subclass/CPC Group	Date	Examiner
	See East Search History	10/30/2017	MW
	See East Search History	02/17/2018	MW

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Reflex USA LLC v. Longyear TM, Inc. and Globaltech Corporation Pty Ltd.

Bibliographic Data

Application No: 14692484

Foreign Priority claimed: ○ Yes ◉ No

35 USC 119 (a-d) conditions met: ☐ Yes ☑ No ☐ Met After Allowance

Verified and Acknowledged: /MICHAEL R WILLS III/ [ ]

Examiner's Signature | Initials

Title: CORE BARREL HEAD ASSEMBLY WITH AN INTEGRATED SAMPLE ORIENTATION TOOL AND SYSTEM FOR USING SAME

FILING or 371(c) DATE	CLASS	GROUP ART UNIT	ATTORNEY DOCKET NO.
04/21/2015	175	3676	36362.0150U2-
RULE			

APPLICANTS

LONGYEAR TM, INC., South Jordan, UT, UNITED STATES

GLOBALTECH CORPORATION PTY LTD, CANNING VALE, AUSTRALIA

INVENTORS

CHRISTOPHER L. DRENTH, Ontario, CANADA

GORDON STEWART, Claremont, AUSTRALIA

KHALED HEJLEH, Peppermint Grove, AUSTRALIA

CONTINUING DATA

This application has PRO of 61982052 04/21/2014

FOREIGN APPLICATIONS

IF REQUIRED, FOREIGN LICENSE GRANTED**

05/01/2015

STATE OR COUNTRY

CANADA

ADDRESS

Ballard Spahr LLP
SUITE 1000
999 PEACHTREE STREET
ATLANTA, GA 30309-3915
UNITED STATES

FILING FEE RECEIVED

$2,780

EAST Search History

EAST Search History (Prior Art)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	Time Stamp
L1	2	("2944792").PN.	US-PGPUB; USPAT; USOCR	ADJ	ON	2018/02/17 15:54
L2	204	(E21B25/16).cpc.	US-PGPUB; USPAT; USOCR	ADJ	ON	2018/02/17 15:57
S1	1	"14692484"	US-PGPUB; USPAT; USOCR	ADJ	ON	2017/06/16 07:57
S2	79	(("DRENTH") near3 ("CHRISTOPHER")).INV.	US-PGPUB; USPAT; USOCR	ADJ	ON	2017/08/10 12:08
S3	145	(("STEWART") near3 ("GORDON")).INV.	US-PGPUB; USPAT; USOCR	ADJ	ON	2017/08/10 12:21
S4	47	(("STEWART") near3 ("GORDON")).INV.	EPO; JPO; DERWENT	ADJ	ON	2017/08/10 12:21
S5	7	(("HEJLEH") near3 ("KHALED")).INV.	US-PGPUB; USPAT; USOCR	ADJ	ON	2017/08/10 14:08
S6	2	("20120145461" | "6732818").PN.	US-PGPUB; USPAT; USOCR	ADJ	ON	2017/08/10 15:04
S7	201	(E21B25/16).cpc.	US-PGPUB; USPAT; USOCR	ADJ	ON	2017/08/10 15:07
S8	440855	(power source or battery) and (body or housing)and (instrument or sensor)	US-PGPUB; USPAT; USOCR	ADJ	ON	2017/08/10 16:21
S9	0	WO "2008113127"	US-PGPUB; USPAT; USOCR	ADJ	ON	2017/08/11 10:41
S10	3	"2008113127"	US-PGPUB; USPAT; USOCR; DERWENT	ADJ	ON	2017/08/11 10:41
S11	201	(E21B25/16).cpc.	US-	ADJ	ON	2017/08/11

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Reflex USA LLC v. Longyear TM, Inc. and Globaltech Corporation Pty Ltd.

			PGPUB; USPAT; USOCR			11:12
S12	48	S11 and (battery or power source)	US-PGPUB; USPAT; USOCR	ADJ	ON	2017/08/11 11:12
S13	3	(US-20150300162-$ or US-20150136488-$ or US-20150029035-$).did.	US-PGPUB	ADJ	ON	2017/08/11 11:15
S14	3	S13 and (battery or power source)	US-PGPUB; USPAT; USOCR	ADJ	ON	2017/08/11 11:15
S15	3	S13 and (battery or power source or power supply)	US-PGPUB; USPAT; USOCR	ADJ	ON	2017/08/11 11:19
S16	48	S11 and (battery or power source or power supply)	US-PGPUB; USPAT; USOCR	ADJ	ON	2017/08/11 11:19
S17	21	S11 and window	US-PGPUB; USPAT; USOCR	ADJ	ON	2017/08/11 11:45
S18	0	702/2.cpc.	US-PGPUB; USPAT; USOCR	ADJ	ON	2017/08/11 11:46
S19	921	702/2.ccls.	US-PGPUB; USPAT; USOCR	ADJ	ON	2017/08/11 11:46
S20	236	S19 and window	US-PGPUB; USPAT; USOCR	ADJ	ON	2017/08/11 11:46
S21	8	S19 and window and core$3 and orientat$3	US-PGPUB; USPAT; USOCR	ADJ	ON	2017/08/11 11:47
S22	606	E21B$.cpc.and window and core$3 and orientat$3 and (battery or power source or power supply)	US-PGPUB; USPAT; USOCR	ADJ	ON	2017/08/11 11:48
S23	606	E21B$.cpc. and window and core$3 and orientat$3 and (battery or power source or power supply)	US-PGPUB; USPAT; USOCR	ADJ	ON	2017/08/11 11:48
S24	263	E21B$.cpc. and window and core$3 and orientat$3 and (battery or power source or power supply) and wireline	US-PGPUB; USPAT; USOCR	ADJ	ON	2017/08/11 11:54
S25	300	E21B$.cpc. and window and core$3 and orientat$3 and (battery or power source or power supply) and (wireline or wire line)	US-PGPUB; USPAT; USOCR	ADJ	ON	2017/08/11 11:54
S26	346	E21B$.cpc. and window and cor$3 and	US-	ADJ	ON	2017/08/11

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		orientat$3 and (battery or power source or power supply) and (wireline or wire line)	PGPUB; USPAT; USOCR			12:07
S27	1730	window and cor$3 and orientat$3 and (battery or power source or power supply) and (wireline or wire line)	US-PGPUB; USPAT; USOCR	ADJ	ON	2017/08/11 12:08
S28	114	S27 AND ((E21B17/028 OR E21B47/09 OR E21B25/16).CPC.)	US-PGPUB; USPAT; USOCR	ADJ	ON	2017/08/11 12:20
S29	2	("20120145461" | "6732818").PN.	US-PGPUB; USPAT; USOCR	ADJ	ON	2017/08/12 14:07
S30	0	("2012/0145461").URPN.	USPAT	ADJ	ON	2017/08/12 14:07
S31	20	("1701724" | "1773915" | "2120240" | "2489566" | "2974739" | "3059707" | "3148740" | "3207239" | "4128134" | "4558749" | "4883131").PN. OR ("6732818").URPN.	US-PGPUB; USPAT; USOCR	ADJ	ON	2017/08/12 14:07
S32	28	("20040036474" | "3618221" | "3875796" | "4128134" | "4311201" | "4389792" | "4765414" | "4883131" | "5048619" | "5052502" | "5105894" | "5310013" | "6006844" | "6082453" | "6412575" | "6592875" | "6659196" | "6732818" | "6871410" | "7296638").PN. OR ("7584055").URPN.	US-PGPUB; USPAT; USOCR	ADJ	ON	2017/08/12 14:07
S33	38	("1773915" | "2652232" | "3115196" | "5957221").PN. OR ("7296638").URPN.	US-PGPUB; USPAT; USOCR	ADJ	ON	2017/08/12 14:08
S34	846	E21B25/00.cpc.	US-PGPUB; USPAT; USOCR	ADJ	ON	2017/08/12 14:09
S35	9	S34 and window and core$3 and orientat$3	US-PGPUB; USPAT; USOCR	ADJ	ON	2017/08/12 14:09
S36	69	S34 and core$3 and orientat$3	US-PGPUB; USPAT; USOCR	ADJ	ON	2017/08/12 14:09
S37	38	("1773915" | "2652232" | "3115196" | "5957221").PN. OR ("7296638").URPN.	US-PGPUB; USPAT; USOCR	ADJ	ON	2017/08/12 14:10
S38	101	("2489566" | "2735652" | "2820610" | "3059707" | "3127943" | "3481412" | "3548958" | "4601354" | "4765414" | "4815342" | "4955438" | "4981183" | "4982802" | "5009273" | "5010765" | "5010789" | "5020612" | "5029653" | "5038873" | "5042596" | "5090492" | "5099934" | "5103921" | "5109935" | "5111892" | "5119892" | "5131478" | "5165494" | "5178222" | "5253720" |	US-PGPUB; USPAT; USOCR	ADJ	ON	2017/08/12 14:11

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Reflex USA LLC v. Longyear TM, Inc. and Globaltech Corporation Pty Ltd.

		"5322135" | "5339915" | "5351765" | "5448227" | "5568838").PN. OR ("6006844").URPN.				
S39	40	("2820610" | "3059707" | "3346059" | "4515225" | "4562560" | "4715022" | "4765414").PN. OR ("4955438").URPN.	US-PGPUB; USPAT; USOCR	ADJ	ON	2017/08/12 14:11
S40	0	("2015/0300162").URPN.	USPAT	ADJ	ON	2017/08/12 14:11
S41	0	("2015/0136488").URPN.	USPAT	ADJ	ON	2017/08/12 14:11
S42	0	("2015/0029035").URPN.	USPAT	ADJ	ON	2017/08/12 14:11
S43	1	"14962484"	US-PGPUB; USPAT; USOCR	ADJ	ON	2017/10/30 11:20
S44	12	"5601152"	US-PGPUB; USPAT; USOCR	ADJ	ON	2017/10/30 11:22
S45	1	"14692484"	US-PGPUB; USPAT; USOCR	ADJ	ON	2017/10/30 11:30
S46	203	(E21B25/16).cpc.	US-PGPUB; USPAT; USOCR	ADJ	ON	2017/10/30 11:35
S47	0	core barrel and cavity and electronic intrument and sensor and power source and core and window	US-PGPUB; USPAT; USOCR	ADJ	ON	2017/10/30 11:37
S48	1	core barrel and cavity and electronic instrument and sensor and power source and core and window	US-PGPUB; USPAT; USOCR	ADJ	ON	2017/10/30 11:37
S49	1	core barrel and cavity and orientation and sensor and power source and core and window	US-PGPUB; USPAT; USOCR	ADJ	ON	2017/10/30 11:38
S50	4551	cavity and orientation and sensor and power source and core and window	US-PGPUB; USPAT; USOCR	ADJ	ON	2017/10/30 11:38
S51	141	electronic instrument and cavity and orientation and sensor and power source and core and window	US-PGPUB; USPAT; USOCR	ADJ	ON	2017/10/30 11:39

EAST Search History (Interference)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	Time Stamp
L3	73	electronic instrument and cavity and orientation and sensor and power source and core and window	USPAT	ADJ	ON	2018/02/17 15:57
L4	0	electronic instrument and cavity and	USPAT	ADJ	ON	2018/02/17

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Reflex USA LLC v. Longyear TM, Inc. and Globaltech Corporation Pty Ltd.

		orientation and sensor and power source and core and window and (wireline or wire line) and orientation				15:59
L5	0	electronic instrument and cavity and orientation and sensor and power source and core and window and (wireline or wire line)	USPAT	ADJ	ON	2018/02/17 15:59
L6	73	electronic instrument and cavity and orientation and sensor and power source and core and window and orientation	USPAT	ADJ	ON	2018/02/17 15:59
L7	71	electronic instrument and cavity and orientation and sensor and power source and core and window and orientation and port	USPAT	ADJ	ON	2018/02/17 15:59
L8	71	electronic instrument and cavity and orientation and sensor and power source and core and window and orientation and port and cavity	USPAT	ADJ	ON	2018/02/17 16:00
S52	0	core barrel and cavity and electronic instrument and sensor and power source and core and window	USPAT	ADJ	ON	2017/10/30 11:37
S53	0	core barrel and cavity and orientation and sensor and power source and core and window	USPAT	ADJ	ON	2017/10/30 11:38
S54	1848	cavity and orientation and sensor and power source and core and window	USPAT	ADJ	ON	2017/10/30 11:38
S55	72	electronic instrument and cavity and orientation and sensor and power source and core and window	USPAT	ADJ	ON	2017/10/30 11:39

2/17/2018 4:01:04 PM
C:\Users\mwills1\Documents\EAST\Workspaces\14692484.wsp

PTO/SB/08a (07-09)
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Substitute for form 1449/PTO

INFORMATION DISCLOSURE STATEMENT BY APPLICANT

(Use as many sheets as necessary)

Sheet 1 of 2

Complete if Known	
Application Number	14/692,484
Filing Date	April 21, 2015
First Named Inventor	Christopher L. Drenth
Art Unit	3676
Examiner Name	M. R. Wills, III
Attorney Docket Number	36362.0150U2-

U. S. PATENT DOCUMENTS

Examiner Initials*	Cite No.[1]	Document Number Number-Kind Code[2] (if known)	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear
	A	US-2,944,792-A	07-12-1960	Gros	

FOREIGN PATENT DOCUMENTS

Examiner Initials*	Cite No.[1]	Foreign Patent Document Country Code[3] Number[4] Kind Code[5] (if known)	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages Or Relevant Figures Appear	T[6]
	B	GB-2243173-A	10-23-1991	Seafloors Eng Inc.		
	C	WO 2008/113127 A	09-25-2008	2iC Australia Pty Ltd.	Corresponds to EP 2134921-A1	

Examiner Signature		Date Considered	

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant. [1] Applicant's unique citation designation number (optional). [2] See Kinds Codes of USPTO Patent Documents at www.uspto.gov or MPEP 901.04. [3] Enter Office that issued the document, by the two-letter code (WIPO Standard ST.3). [4] For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. [5] Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. [6] Applicant is to place a check mark here if English language Translation is attached.

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Dated: January 24, 2018 Signature: /Joseph P. Anderson, III/ (Joseph P. Anderson, III)

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(Use as many sheets as necessary)

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NON PATENT LITERATURE DOCUMENTS

Examiner Initials*	Cite No.[1]	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc.), date, page(s), volume-issue number(s), publisher, city and/or country where published.	T[2]
	D	Extended European Search Report issued on October 17, 2017 by the European Patent Office for Application No. 15782230.5, which was filed on April 21, 2015 and published as EP 3134600 on March 1, 2017 (Inventor- Drenth et al.; Applicant- Longyear TM, Inc. et al.; Attorney Docket No.- 36362.0150EP1) (9 pages).	

Examiner Signature	/MICHAEL R WILLS III/	Date Considered	02/17/2018

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U. S. PATENT DOCUMENTS

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	A	US-2,944,792-A	07-12-1960	Gros	

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	C	GB-2243173-A	10-23-1991	Seafloors Eng Inc		

Examiner Signature	/MICHAEL R WILLS III/	Date Considered	02/17/2018

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Dated: January 17, 2018 Signature: /Joseph P. Anderson, III/ (Joseph P. Anderson, III)

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Attorney Docket Number	36362.0150U2-

Sheet	2	of	2

NON PATENT LITERATURE DOCUMENTS

Examiner Initials*	Cite No.[1]	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc.), date, page(s), volume-issue number(s), publisher, city and/or country where published.	T[2]
	D	Extended European Search Report issued on October 17, 2017 by the European Patent Office for Application No. 15782230.5, which was filed on April 21, 2015 and published as EP 3134600 on March 1, 2017 (Inventor- Drenth et al.; Applicant- Longyear TM, Inc. et al.; Attorney Docket No.- 36362.0150EP1) (9 pages).	

Examiner Signature		Date Considered	

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[1] Applicant's unique citation designation number (optional). [2] Applicant is to place a check mark here if English language Translation is attached.

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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
14/692,484	04/21/2015	CHRISTOPHER L. DRENTH	36362.0150U2-	3851

7590 01/24/2018

Ballard Spahr LLP
SUITE 1000
999 PEACHTREE STREET
ATLANTA, GA 30309-3915

EXAMINER	
WILLS III, MICHAEL R	

ART UNIT	PAPER NUMBER
3676	

NOTIFICATION DATE	DELIVERY MODE
01/24/2018	ELECTRONIC

NOTICE OF NON-COMPLIANT INFORMATION DISCLOSURE STATEMENT

An Information Disclosure Statement (IDS) filed (2) 1/17/2018 in the above-identified application fails to meet the requirements of 37 CFR 1.97(d) for the reason(s) specified below. Accordingly, the IDS will be placed in the file, but the information referred to therein has not been considered.

The IDS is not compliant with 37 CFR 1.97(d) because:

☒ The IDS lacks a statement as specified in 37 CFR 1.97(e).

☐ The IDS lacks the fee set forth in 37 CFR 1.17(p).

☐ The IDS was filed after the issue fee was paid. Applicant may wish to consider filing a petition to withdraw the application from issue under 37 CFR 1.313(c) to have the IDS considered. See MPEP 1308.

571-272-4200 or 1-888-786-0101
Application Assistance Unit
Office of Data Management

FORM PTOM327-B (Rev. 02/08)

Ex.2001 / IPR2023-00642 / Page 35 of 870
Reflex USA LLC v. Longyear TM, Inc. and Globaltech Corporation Pty Ltd.

Doc code: RCEX
Doc description: Request for Continued Examination (RCE)

PTO/SB/30EFS (07-14)
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REQUEST FOR CONTINUED EXAMINATION(RCE)TRANSMITTAL
(Submitted Only via EFS-Web)

Application Number	14/692,484	Filing Date	2015-04-21	Docket Number (if applicable)	36362.0150U2	Art Unit	3676
First Named Inventor	Christopher L. Drenth			Examiner Name	Michael R. Wills III		

This is a Request for Continued Examination (RCE) under 37 CFR 1.114 of the above-identified application.
Request for Continued Examination (RCE) practice under 37 CFR 1.114 does not apply to any utility or plant application filed prior to June 8, 1995, to any international application that does not comply with the requirements of 35 U.S.C. 371, or to any design application. The Instruction Sheet for this form is located at WWW.USPTO.GOV.

SUBMISSION REQUIRED UNDER 37 CFR 1.114

Note: If the RCE is proper, any previously filed unentered amendments and amendments enclosed with the RCE will be entered in the order in which they were filed unless applicant instructs otherwise. If applicant does not wish to have any previously filed unentered amendment(s) entered, applicant must request non-entry of such amendment(s).

☐ Previously submitted. If a final Office action is outstanding, any amendments filed after the final Office action may be considered as a submission even if this box is not checked.

- ☐ Consider the arguments in the Appeal Brief or Reply Brief previously filed on _____
- ☐ Other _____

☒ Enclosed

- ☐ Amendment/Reply
- ☒ Information Disclosure Statement (IDS)
- ☐ Affidavit(s)/ Declaration(s)
- ☐ Other _____

MISCELLANEOUS

☐ Suspension of action on the above-identified application is requested under 37 CFR 1.103(c) for a period of months _____ (Period of suspension shall not exceed 3 months; Fee under 37 CFR 1.17(i) required)

☐ Other _____

FEES

☒ **The RCE fee under 37 CFR 1.17(e) is required by 37 CFR 1.114 when the RCE is filed.**
The Director is hereby authorized to charge any underpayment of fees, or credit any overpayments, to Deposit Account No 140629

SIGNATURE OF APPLICANT, ATTORNEY, OR AGENT REQUIRED

☒ Patent Practitioner Signature

Applicant Signature

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Signature of Registered U.S. Patent Practitioner			
Signature	/Joseph P. Anderson, III/	Date (YYYY-MM-DD)	2018-01-24
Name	Joseph P. Anderson, III	Registration Number	59245

This collection of information is required by 37 CFR 1.114. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450.

If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.

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The Privacy Act of 1974 (P.L. 93-579) requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

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5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.

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7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.

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Electronic Patent Application Fee Transmittal

Application Number:	14692484
Filing Date:	21-Apr-2015
Title of Invention:	CORE BARREL HEAD ASSEMBLY WITH AN INTEGRATED SAMPLE ORIENTATION TOOL AND SYSTEM FOR USING SAME
First Named Inventor/Applicant Name:	CHRISTOPHER L. DRENTH
Filer:	Joseph P. Anderson
Attorney Docket Number:	36362.0150U2-

Filed as Large Entity

Filing Fees for Utility under 35 USC 111(a)

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
Pages:				
Claims:				
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				
Extension-of-Time:				

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Miscellaneous:				
RCE- 1st Request	1801	1	1300	1300
		Total in USD ($)		**1300**

Electronic Acknowledgement Receipt	
EFS ID:	31588193
Application Number:	14692484
International Application Number:	
Confirmation Number:	3851
Title of Invention:	CORE BARREL HEAD ASSEMBLY WITH AN INTEGRATED SAMPLE ORIENTATION TOOL AND SYSTEM FOR USING SAME
First Named Inventor/Applicant Name:	CHRISTOPHER L. DRENTH
Customer Number:	23859
Filer:	Joseph P. Anderson
Filer Authorized By:	
Attorney Docket Number:	36362.0150U2-
Receipt Date:	24-JAN-2018
Filing Date:	21-APR-2015
Time Stamp:	11:53:56
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment Type	CARD
Payment was successfully received in RAM	$1300
RAM confirmation Number	012418INTEFSW11565700
Deposit Account	
Authorized User	
The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows:	

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Foreign Reference	WO2008113127A1.pdf	1860966 5cc95590d8787da65b518fceab0edf0e1f1d5831	no	49
Warnings:					
Information:					
2	Foreign Reference	GB2243173A.pdf	1843683 ed93de9e99906815387816a3ad01020f5f0beb84	no	48
Warnings:					
Information:					
3	Non Patent Literature	36362_0150EP1_ESSR_2017_10_17.pdf	344959 0783a4eb1fd77febd2d014318d623e6ed7c5f446	no	9
Warnings:					
Information:					
4	Transmittal Letter	36362_0150U2_SIDS_Transmittal_2018_01_24.pdf	119893 f9cc0d4572acdeb653b61f65db5a6c169bcf4365	no	2
Warnings:					
Information:					
5	Information Disclosure Statement (IDS) Form (SB08)	36362_0150U2_SIDS_SB08_2018_01_24.pdf	184182 e6b1fd9887adc15db8e050c99c59f848b7538846	no	2
Warnings:					
Information:					
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6	Request for Continued Examination (RCE)	36362_0150U2_RCE.pdf	1350063 094dc9c4d41e5db98df300118b827ab8eac4c731	no	3
Warnings:					

Information:					
7	Fee Worksheet (SB06)	fee-info.pdf	30536 4eb91a936cac128d8e8cc8fc3ce899f428608890	no	2
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Information:					
			Total Files Size (in bytes):	5734282	

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New Applications Under 35 U.S.C. 111

If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

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(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
25 September 2008 (25.09.2008)

PCT

(10) International Publication Number
WO 2008/113127 A1

(51) International Patent Classification:
E21B 25/16 (2006.01) *E21B 49/02* (2006.01)

(21) International Application Number:
PCT/AU2008/000395

(22) International Filing Date: 19 March 2008 (19.03.2008)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
2007901412 19 March 2007 (19.03.2007) AU

(71) Applicant *(for all designated States except US)*: **2iC AUSTRALIA PTY LTD** [AU/AU]; Unit 2/10 McElligott Court, Canning Vale, Western Australia 6155 (AU).

(72) Inventors; and
(75) Inventors/Applicants *(for US only)*: **BEACH, Andrew** [AU/AU]; Level 2/10 McElligott Court, Canning Vale, Western Australia 6155 (AU). **BEACH, Shayne** [AU/AU]; Unit 2/10 McElligott Court, Canning Vale, Western Australia 6155 (AU). **MCLEOD, Gavin** [AU/AU]; Unit 2/10 McElligott Court, Canning Vale, Western Australia 6155 (AU).

(74) Agent: **GRIFFITH HACK**; Level 19, 109 St George's Terrace, Perth, WA 6000 (AU).

(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, 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, HR, HU, IE, IS, IT, LT, LU, LV, MC, MT, NL, NO, 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*

(54) Title: A CORE ORIENTATION TOOL

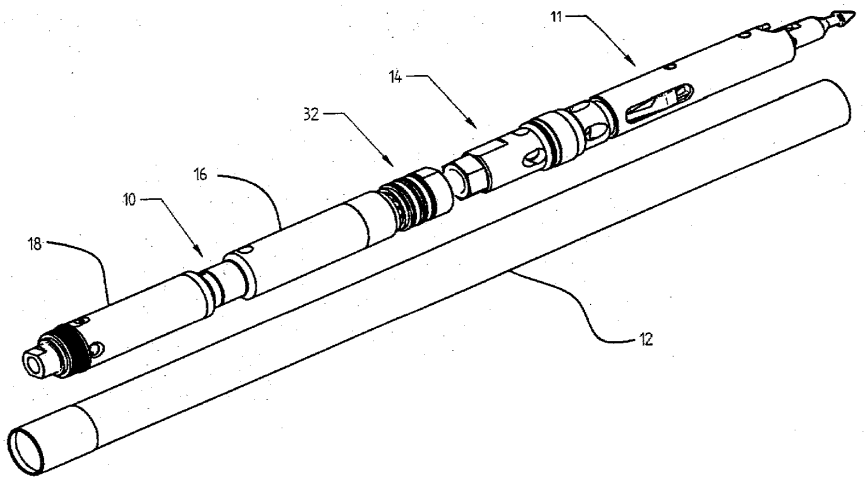


Figure 1

(57) Abstract: A core orientation tool (10) for providing an indication of orientation of a core sample (112) comprises an electronic orientation device (20), which upon receipt of a trigger signal, logs one or more indications of orientation of the tool (10). A trigger system (24) provides trigger signals to the electronic device (20) based one or both of (a) detecting one or more downhole events and (b) the effluxion of time. The downhole events relate to the action of core breaking and may include detecting: uphole motion of the tool; and, cessation of drilling and commencement of drilling.

WO 2008/113127 A1

A CORE ORIENTATION TOOL

Field of the Invention

The present invention relates to a core orientation tool that can provide directional characteristics of a geological core sample extracted from the subsurface.

Background of the Invention

Core sampling is used to allow geological surveying of the subsurface for various purposes including exploration and/or mine development. An analysis of the material within the core sample provides information of the composition of the subsurface. However in order to accurately interpret the information obtained from the core sample, it is necessary to have knowledge of the orientation of the core sample relative to the subsurface from which it was extracted.

Applicant has developed numerous devices, systems and methods for orientating a core sample including a method of orientating a core sample described in co-pending Australian patent application no. 2006901298; an orientation head described in International publication No. WO 07/109848; a core orientation system described in International publication No. WO 07/1137356; and an orientation device for a core sample described in International publication No. WO 03/038232; the contents of each of which is incorporated herein by way of reference.

The present invention is the result of Applicant's further research and development in the field of core orientation.

It is to be understood that, if any prior art publication is referred to herein, such reference does not constitute

an admission that the publication forms a part of the common general knowledge in the art, in Australia or any other country.

In the claims of this application and in the description of the invention, except where the context requires otherwise due to express language or necessary implication, the words "comprise" or variations such as "comprises" or "comprising" are used in an inclusive sense, i.e. to specify the presence of the stated features but not to preclude the presence or addition of further features in various embodiments of the invention.

Summary of the Invention

According to a first aspect of the present invention there is provided a core orientation tool for providing an indication of *in situ* orientation of a core sample extracted from a borehole by a core drill the tool comprising:

an electronic orientation system coupled with the core drill, the electronic orientation system configured, upon receiving a trigger signal, to log one or more first indications of orientation of the tool; and,
a trigger system that provides the trigger signal upon detecting one or more downhole events associated with operation of the core drill.

According to a second aspect of the present invention there is provided a core orientation tool for providing an indication of *in situ* orientation of a core sample extracted from a borehole by a core drill the tool comprising:

an electronic orientation system coupled with the core drill, the electronic orientation system configured, upon

receiving a trigger signal, to log one or more first indications of orientation of the tool; and,
a trigger system that provides the trigger signal upon one or both of (a) detecting one or more downhole events associated with operation of the core drill, and (b) effluxion of time.

According to a third aspect of the present invention there is provided a core orientation tool for providing an indication of *in situ* orientation of a core sample extracted from a borehole by a core drill the tool comprising:

an electronic orientation system coupled with the core drill, the electronic orientation system configured to log one or more first indications of orientation of the tool; and,
a trigger system that provides a trigger signal upon detecting one or more downhole events associated with operation of the core drill; and,
wherein tool is configured to associate the one or more first indications of orientation with the trigger signal.

The trigger signal may be one of a plurality of trigger signals. Moreover, the tool may be further configured to log different first indications of orientation, for example dip, roll and azimuth upon receipt of different trigger signals.

The one or more downhole events may comprise respective physical events arising from motion of the tool or the drill in the borehole.

For example, the motion may comprise one or a combination of:
(a) motion in an uphole direction;

(b) a change in motion from motion having a linear component in a downhole direction to motion having no linear component;

(c) a change in motion from motion in a downhole direction to motion in an uphole direction;

(d) a change in motion from no linear motion to motion in an uphole direction;

(e) a change in characteristics of vibration motion on the tool or drill arising from the cessation or commencement of drilling;

(f) a change in speed of linear motion of the tool; and,

(g) a change in the rate or direction of rotation around the tool's longitudinal, lateral or normal axis.

(h) any change in velocity (speed and/or direction of movement).

The trigger signal may be provided upon detecting a predetermined sequence of downhole events such as a cessation of drilling followed by motion of the tool in an uphole direction.

The sequence of events may further comprise commencement of drilling prior to the cessation of drilling.

Other downhole events that may be detected by the electronic orientation device and used in producing the trigger signal comprise:
(a) detecting contact of a backend assembly to which the tool is coupled hitting a landing ring in the core drill;

(b) the backend assembly hitting a water table in the event that the drill is operated in the borehole below the water table;

(c) detecting release of the backend assembly from a wire line when initially inserting a core tube into the core drill;

(d) the core drill tagging a toe of the hole;

(e) an overshot hitting and latching onto the backend assembly;

(f) retrieval of the backend assembly from the drill hole; and,

(g) a change in the flow of fluid through or around the backend assembly.

Instead of utilising detected changes in vibration characteristics of the tool which are caused when the drill is cutting a core, the stopping and starting of drilling may be detected by sensing actual rotation of the core drill by using sensors or devices mounted on or adjacent to a rotating side of the backend assembly. Such devices may comprise an inductive RPM sensor, accelerometer or a gyroscope.

The tool 10 may be further configured to log or record time between one or more of the downhole events, for example the time between cessation of drill and motion in an uphole direction; and/or time between cessation of drilling and the provision of the trigger signal. Such information may be beneficial in accessing the accuracy or degree of confidence in the orientation readings.

According to a further aspect of the present invention there is provided a core retrieval system for a core drill comprising:

a core tube having an uphole end and a downhole end, the downhole end provided with an opening for receiving a core sample cut by the core drill; and,

a core orientation tool in accordance with the first aspect of the present invention wherein the core orientation tool is coupled to the core tube at a location uphole of the downhole end of the core tube.

The core retrieval system may further comprise a backend assembly coupled to the uphole end of the core tube and wherein the core orientation tool is attached to the backend assembly uphole of the uphole end of the core tube.

A further aspect of the present invention provides a method of logging *in situ* orientation of a core sample extracted from the ground by a core drill comprising:

coupling an electronic core orientation device in a known spatial relationship to a core sample cut by the core drill;

configuring the electronic core orientation device to log one or more indications of orientation of the device upon receipt of a trigger signal; and,

providing the trigger signal upon detecting one or more downhole events associated with the operation of the core drill.

The downhole events may be indicative of a, or an imminent, core break.

Detecting of the one or more downhole events may comprise detecting an uphole motion of the device.

The detecting of the downhole event may comprise detecting a cessation of drilling prior to detecting the uphole motion of the device. The detecting may further comprise detecting commencement of drilling prior to detecting cessation of drilling. Further, the detecting may comprise detecting a cessation of downhole movement of the device prior to detecting the commencement of drilling.

In one embodiment the tool comprises a switch that is activated by the tool, a downhole device such as an inner barrel assembly to which the tool is attached, or the drill, tagging the toe of the borehole. The switch may comprise a Hall effect switch, an optical switch, a pressure switch, and a mechanically operated electrical switch.

The first indications of orientation may comprise one or a combination of borehole dip, borehole azimuth, core orientation, core dip and core azimuth.

According to a further aspect of the present invention there is provided a core retrieval system for a core drill comprising:

an inner core tube having an uphole end and an opposite downhole end provided with an opening for receiving a core cut by the core drill; and,

a core orientation tool coupled to the inner core barrel and movable inside the inner core tube in an uphole direction by abutment with the core, the core orientation tool comprising an electronic orientation device which upon receiving a trigger signal logs one or more first indications of orientation of the tool;

a trigger system that provides the trigger signal to the electronic orientation device; and

a core face orientation device which records rotational orientation of a core sample, wherein the electronic orientation device is in a known rotational position relative to the core face orientation device.

According to another aspect of the present invention there is provided a core retrieval system for a core drill comprising:

a core tube having an uphole end and an opposite downhole end provided with an opening for receiving a core sample cut by the core drill;

a core orientation tool coupled to the inner core tube and movable inside the inner core barrel in an uphole direction by abutment with the core sample, the core orientation tool comprising: an electronic orientation device which, upon receiving a trigger signal logs one or more first indications of orientation of the tool; and a trigger system that provides the trigger signal to the electronic orientation device.

A further aspect of the present invention provides a core orientation apparatus for providing an indication of orientation of a core sample extracted from a borehole by a core drill the apparatus comprising:

an electronic orientation device which upon receiving a trigger signal logs one or more first indications of orientation of the tool;

a trigger system that provides the trigger signal to the electronic orientation device; and

one or more secondary orientation devices which provide one or more second indications of orientation of the core or borehole, wherein the electronic orientation device is in a known rotational position relative to the one or more secondary orientation devices.

The trigger system may provide the trigger signal on the basis of effluxion of time from a reference time. For example the reference time could be the time the tool is inserted into a core drill, or at a time when or after the core face orientation device records the orientation of the core face.

In an alternate embodiment, the trigger signal is delivered on multiple occasions during a period between the core orientation tool being inserted into the core drill and a time after the core face orientation device records the orientation of the core face.

In one embodiment, the trigger system provides the trigger signal to the electronic orientation device upon detecting one or more downhole events associated with the operation of the drill. The one or more downhole events may comprise one or more physical events arising from the motion of the tool in the borehole.

Brief Description of the Drawings

Embodiments of the present invention will now be described by way of example only with reference to the accompanying drawings in which:

Figure 1 is a schematic representation of an inner barrel assembly and core tube to which an embodiment of a core orientation tool is coupled;

Figure 2 is a cutaway view of the core orientation tool and adjacent parts of the inner barrel assembly to which it is coupled.

Figure 3 is a partially exploded schematic representation of a further embodiment of a core orientation tool in accordance with the present invention;

Figure 4 is a partially exploded representation of a third embodiment of the core orientation tool;

Figure 5 is a section view of the core orientation tool shown in Figure 4; and

Figure 6 depicts the use of a template for transferring indications of core orientation captured by the tool to a core.

Detailed Description of the Preferred Embodiment

Throughout this specification the term "orientation" is intended to mean one or more of "dip", "roll", and "azimuth" of an apparatus, tool, core sample, borehole, or other structure in relation to which orientation data is required or desired.

Further, the expression "electronic orientation device" is intended to denote an electronic device or system that utilises electronic sensors and transducers such as but not limited to accelerometers, inclinometers, gyroscopes and magnetometers.

Throughout this specification the expression "downhole direction" is intended, unless the context clearly suggests otherwise, a direction that increases distance along the hole away from a collar of the hole. Thus for example in a hole drilled directly downwards in the ground the downhole direction is the same as the direction of gravitational acceleration. Whereas in an uphole such as one drilled in a back of a tunnel, the downhole direction is in a direction opposite to the direction of gravitational acceleration.

Throughout this specification the expression "uphole direction" is intended, unless the context clearly

suggests otherwise, a direction that decreases distance along the hole away from the collar of the hole. Thus for example in a hole drilled directly downwards in the ground the uphole direction is opposite the direction of gravitational acceleration. Whereas in an uphole such as one drilled in a back of a tunnel, the uphole direction is the same as the direction of gravitational acceleration.

Figures 1 and 2 illustrate an embodiment of a core orientation tool 10 in accordance with the present invention. The core orientation tool 10 is shown in association with an inner barrel assembly 11 which comprises a core tube 12 for receiving a core being cut by a core drill, and a backend assembly 14 that is attached to the core tube 12 for lowering and retrieving the core tube 12 from the core drill. The core tube 12 is of conventional construction while the backend assembly 14 is modified by the inclusion of an adaptor 16. The tool 10 is coupled at one end to the conventional core tube cap 18 of the backend assembly 14 with the adaptor 16 being used to couple an opposite end of the tool 10 to the remainder of the backend assembly 14. The tool 10 is in a known or measurable spatial relationship with the core tube 12. Further, as the core sample is rotationally fixed inside the core tube 12, at least shortly before and during a core breaking action, the orientation data relating to the core tube 12 can be related to the *in situ* orientation of the core sample.

The tool 10 comprises an electronic core orientation device or system 20 housed within a body 22 that is coupled to and between the core tube cap 18 and the adaptor 16. The electronic core orientation device 20 is configured to log one or more first indications of orientation of the tool (ie, core orientation) upon receiving of a trigger signal. To this end, the tool 10 includes a trigger system 24 that provides the trigger

signal upon detecting one or more downhole events associated with the operation of the core drill. These events may particularly relate to the core breaking function of the core drill and/or various sequences of events expected prior to core breakage.

The system 20 comprises multiple sensors and transducers for sensing various events and orientation data of the tool 10 and core drill. The sensors may comprise for example accelerometers, gyroscopes, physical switches, magnetometers, vibration sensors, inclinometers, inductive RPM sensors, flow sensors and pressure sensors. Some of the sensors and transducers send information to the trigger system that analyses the information to determine when to provide the trigger signal. Other sensors and transducers, notionally forming an orientation module 26, may be either in an idle state or continually providing data indicative of core and/or bore hole orientation, however these sensors and transducers are not activated and/or the orientation data is not logged until the trigger system 24 provides the trigger signal. It will be appreciated by those skilled in the art that some of the sensors and transducers that are used by the trigger system may also provide orientation data. The orientation system 20 may further comprise a transceiver 28 coupled to an antenna 30 to communicate with a hand-held computer or other like device. The function of this will be explained in greater detail later in the specification.

Embodiments of the tool 10 are able to log *in situ* orientation data relating to the core and the borehole from which the core is extracted at a time shortly before or at core breakage. This is done by arranging a trigger system 24 to issue the trigger signal upon sensing particular events or sequences of events that are expected to occur when a core is broken from the ground. One or more of the downhole events relate to physical events

arising from the motion of the tool 10 and indeed the core drill in the borehole. One of the telltale physical events of a core break is an uphole motion of the core drill and thus the tool 10. Accordingly the trigger system 24 may be configured to issue the trigger signal when sensors in the module 26 detect an uphole movement or acceleration or a change in direction of motion from a downhole direction to an uphole direction. While such motion is characteristic of a core break, other events or motions may also be sensed which increase the degree of confidence that the uphole motion is related to a core break. Examples of such events or motions include:

1. The backend assembly 14 being released at the collar of the borehole.

2. When the toe of the hole is below the water table, detecting the backend assembly 14 hitting the water table.

3. The backend assembly 14 contacting or hitting a landing ring within the core drill.

4. The commencement of drilling.

5. The cessation of drilling.

6. The breaking of the core itself.

7. An overshot hitting and latching onto the backend assembly 14.

For example, in addition to simply detecting an uphole motion of the tool 10 or the core tube 12 or core drill itself, the trigger system 24 may be arranged to issue the trigger signal upon the module detecting in sequence commencement of drilling, cessation of drilling and a

motion in an uphole direction. The sensing of the commencement and cessation of drilling may be via the use of vibration sensors in the module 26. It is known that during drilling as a core bit is bearing against rock, vibrations of known characteristics will be generated.

The trigger signal may be one of a plurality of trigger signals provided upon detection of different downhole events. That is a trigger signal may be provided when commencement of drill is detected, another when cessation of drilling is detected and another when an uphole motion of the tool 10 or drill is detected. Thus logging (recording) of data will commence prior to the breaking of the core. Additionally different orientation indications may be logged at different trigger signals. For example dip may be logged at when the trigger system detects drilling has stopped (e.g. detecting no rotation of the core drill following previously detecting the commencement of drilling; and core orientation may be logged upon the trigger system detecting a core lifter case gripping the core just prior to the core break.

The tool 10 and more particularly the electronic orientation system 20 comprises a memory device for storing logged data. The trigger signal may be considered to act as a pointer to identify the logged orientation data at the time the trigger signal(s) where provided so that the orientation data can be correlated to particular downhole event, particularly the core break.

Accordingly sensing a change in the characteristics of the vibrations would be indicative of the commencement and cessation of drilling. However this is not the only way in which the commencement and cessation of drilling may be sensed. As an alternate, sensors may be provided in the module 26 or trigger system 24 to sense the speed, direction or change in speed or direction of rotation of

the core drill. For example upon commencement of drilling, the sensor will detect rotation of the core drill, while on cessation of drilling the sensor will subsequently detect a change in the speed of rotation and more particularly a zero speed of rotation. Such a sensor may comprise an inductive RPM sensor, accelerometer or gyroscope having a component on or adjacent a rotating section of the backend assembly 14, such as for example on an uphole side of bearing 32 of the backend assembly.

Other possible variations for detecting the commencement and cessation of drilling include by detecting flow of fluid through or around the backend assembly 14. In this regard, fluid is pumped through or around the core drill and backend assembly during drilling with the flow being cut off when drilling ceases. Therefore detecting a change in the flow of water will also be indicative of the cessation of drilling. Also while uphole motion may typically be sensed by an accelerometer, other types of sensors including optical sensors or lasers may be used for sensing motion in an uphole direction.

A substantive benefit of the tool 10 over other core orientation devices that rely on the logging of time to correlate orientation data to a core is that the tool 10 does not require the use of timers by human operators and is therefore less susceptible to error. The above described embodiment of the tool 10 may be considered as a "drop and forget" sensor which will automatically log core orientation data shortly before or at the time of a core break.

The tool 10 may be further configured to provide borehole azimuth and vertical core orientation relative to azimuth. It is known to use gyroscopes to obtain azimuth information when logging boreholes. However gyroscope technology is not suitable for use in downhole core

orientation during the drilling process. The reasons for this include that the gyroscopes are prone to drift when operated for extended periods as would be required when lowering the gyroscope through the core drill; the inability for the gyroscope to maintain accurate orientation when exposed to sudden movements such as a shunt or vibration as typically would occur when dropping a backend assembly down a drill string; and, the need for the azimuth measurement to be made relative to a known reference point.

Notwithstanding the above limitations, an embodiment of the tool 10 may comprise a gyroscope 34 or similar device for logging azimuth and dip. This is enabled by the use of the trigger system 24 which will only trigger the gyroscope 34 to move from an off or idle state to a logging state at the same time as it supplies a trigger signal to the measurement module 26. Prior to the trigger system 24 providing the trigger signal, the gyroscope 34 is either off or in an idle state. Upon receipt of the trigger signal, the gyroscope 34 is activated to commence tracking changes in orientation.

As the inner barrel assembly 11 is being withdrawn from the core drill, the gyroscope 34 continues to tracking changes in orientation. Orientation of a collar of the borehole may be used as a known reference orientation. Thus changes in orientation since the issuance of the trigger signal can be related back to the collar orientation so as to enable determination of the azimuth of the tool 10 and the borehole at the toe of the hole substantially at the time of a core break. This in effect provides a single survey shot at the bottom of the hole. This data may be used to build an ongoing survey of the borehole for determining its path when combined with a measurement or estimate of the hole depth. This may be

determined by simply counting the number of rods in the core drill at each core run.

As the gyroscope 34 will only need to track changes in the orientation of the tool 10 after drilling has stopped, the need to track changes during the descent of the tool down the hole and during drilling is avoided. This substantially reduces the running time of the gyroscope therefore reducing the drift that may occur. It also obviates the need for the gyroscope to track changes in high vibration periods during drilling thus avoiding a significant loss of accuracy.

In the above embodiment, the tool 10 is used as a stand alone tool to obtain orientation data. In order to extract the data and relate the data to a core sample held within the core tube 12, the tool 10 may be used in conjunction with a core orientation system of the type described in Applicant's International application No. WO 2007/137356. In brief, the core orientation system in the abovereferenced publication comprises a combination of:

an electronic orientation device which may have some features common to the current device 10;

a core position indicator adapted for engagement with the core tube 12 when on the ground; and,

a remote unit such as a hand-held computer that communicates between the tool 10 and the core position indicator.

In short, the transceiver 28 in the tool 10 communicates via wireless communication with the hand-held computer which in turn transfers data to the core position indicator. More particularly, the tool 10 logs orientation data of a reference point on the core tube 12

relative to a first datum at the time the particular downhole event has occurred, ie, at or shortly before a core break. The reference point on the core tube need not be a physical marking. Once the core tube 12 is retrieved and placed in a stable position say on a core tray, the tool 10 is again operated to log orientation data of the same reference point on the core tube to a second datum. A rotational displacement σ from the first datum to the second datum is calculated by the hand-held computer and wirelessly communicated to the core position indicator. The core position indicator is then rotated about the core tube 12. When the core position indicator is moved to a position where it is rotated by the appropriate rotational displacement σ from the second datum, it emits a signal to indicate the position of the first datum.

The core position indicator also includes a guide in the form of a slat having an elongated slot for receiving a scribing or marking device such as a pencil. The forward most end of the slat extends over the front of a core lifter case 36 and a portion of the core extending from the core lifter case. The marker is then used to mark the core lifter case and/or core to signify the location of the core relative to the particular datum.

The core position indicator may be modified over and above that described in the above referenced application by the inclusion of a sensor to sense when a marker has been run along the slot to signify that a marking has been made on the core lifter case and/or core. The core position indicator and the hand-held computer can record how accurately an operator marks the core by comparing its position when marked to its required position. This accuracy of marking information can then be transferred back to the hand-held computer and integrated with the original orientation information. The information contained in the hand-held computer is transferable to a

removal medium so that all the information can be provided to the recipient of the core.

Alternately, the core position indicator may be arranged so as to prevent a user from marking the core until the core position indicator is correctly orientated. This may be achieved for example by having a moveable gate that slides across the slot to block the slot when the core position orientator is not in the correct orientation.

In one variation the trigger system may be modified to provide trigger signals on based on one or both of (a) one or more downhole events, and (b) effluxion of time.

The time triggers may comprise one or a combination of:

(a) a single trigger at a specified delay time relative to a time the device was initialized by an operator or triggered by a physical event;

(b) multiple continuous triggers at preset intervals commencing at a specified delay time relative to a time the device was initialized by an operator or triggered by a physical event and from which one or more data sets are selected.

The trigger system 24 may trigger the sensors in the module 26 to record one, or a combination of readings of orientation at a point/points in time:

(a) exactly when the trigger occurs;

(b) after some time delay;

(c) prior to the trigger by selecting a pre recorded reading where multiple readings are taken at predetermined intervals.

The trigger system 24 may cyclically provide trigger signals for a prescribe period of time after the first trigger is provided. For example trigger signals may be

provided every 10 seconds for a two minute period. Alternately, the electronic orientation device 20 may be arranged so that upon receiving a trigger signal, it logs the one or more first directional characteristics cyclically for a prescribed period of time, for example every 10 seconds for a 2 minute period.

Figures 3-6 illustrate various core orientation apparatuses 100 which comprise a combination of the core orientation tool 10 together with one or more secondary orientation devices. As described in greater detail below, one of the secondary orientation devices may be a core face orientation device which records the *in situ* orientation of the face of the core. Another secondary orientation device that may be incorporated into the apparatuses 100 is a bottom orientator which records the location of a zero gravity vector at the toe of the hole provided that the hole is inclined to the vertical. The secondary orientation devices may be mechanical or electronic.

In the embodiment of the apparatus 100 shown in Figure 3, the trigger system 26 is depicted as being contained in the common housing 22 with the remainder of the electronic system 20. However this need not be the case and the trigger system 26 may be physically separate from the tool 100 but in communication remainder of the electronic system 20 (for example by radio communication) to allow delivery of the trigger signals.

The trigger system 24 may provide trigger signals based on the same downhole events described in relation to the first embodiment.

This embodiment of the apparatus 100 comprises: a secondary orientation device which provides core face orientation and is in the form of a profile device 120;

and, body 122 having a downhole end 124 and an uphole end 126. The body 122 comprises a lock body 127, a latch body 128 and an anchor 130, which are described in detail hereinafter with reference to the embodiment shown in Figures 5 and 6. In the embodiment of Figure 3, the electronic orientation device 20 is located downhole of the body 122.

The device 120 may take the form of the face orientator as described in Applicant's above referenced International publication No. WO 07/109848. The device 120 comprises a substantially cylindrical body 132 having a plurality of internal axially extending holes 134 for seating respective pins 136. The pins 136 are held within the holes 134 with a degree of resilience so that if an axial force is placed on the pins 136 in the uphole direction, the pins 136 can slide within the body 132, but when the force is removed, the pins 136 maintain their relative position in their holes 134. The body 132 is also provided with a bearing scale 138 marked on its outer circumferential surface 140. The scale provides markings in five degree increments from 0° to 360°. The 0° mark is aligned with a positional reference mark 142 provided at a downhole end of a shaft 144 that extends into the electronic orientation device 20.

The mark 142 also provides a zero reference for the electronic orientation device 20 so that by coupling of the device 120 to the electronic device 20 both are keyed to the same zero reference.
The face orientator 120 provides a profile recording of a toe of the hole from which a core 112 is cut. It will be understood by those skilled in the art that the toe of the hole becomes an uphole face of the core 112. Typically the device 120 is constructed as a single use device that, upon extraction of the core, is removed from the apparatus 100 and is stored with the core 112. Prior to this

occurring, the scale 138 is marked with an angle denoting the orientation of the core relative to the zero degree mark on the scale 138. This marking may be obtained by transferring data from the electronic device 20 to the device 120 by an intervening hand held telemetry device (hand held computer) that interrogates the device 20 to obtain for example the tool face orientation data at the time the trigger signal is provided by the triggering system 26. This will provide for example a bearing in degrees referenced to the reference mark 142. This bearing can then be physically marked on the scale 138. For example if the tool face orientation was 35° relative to the marking 142, then an indelible mark can then be made on the 35° position on the scale 138.

Figure 4 illustrates a further embodiment of the apparatus 100. In this figure the features which are identical to those described with reference to Figure 3 are denoted by the same reference numbers. The substantive difference between the apparatus 100 shown in Figure 4 and that shown in Figure 3 is that the tool 10 in Figure 4 is located at the uphole end 126 of the body 122 and, an additional secondary orientation device in the form of a mechanical bottom orientator 146 is coupled between the downhole end 124 of the body 122 and the core face profile device 120. The bottom orientator 146 is provided with three balls 148a, 148b and 148c (hereinafter referred to in general as "balls 148") disposed within respective races 150a, 150b, and 150c (hereinafter referred to in general as "races 150"). Prior to the bottom orientator 146 being activated the balls 148 are free to roll within their respective races 150. Accordingly, by action of gravity, provided that the apparatus 100 is disposed in a borehole that is not absolutely vertical, the balls 148 will roll to the lowest point within their respective races. When the bottom orientator 146 is activated, the width of the races 150 is reduced so that the balls 148 are clamped in their

races. This prevents any further rolling of the balls and thus maintains the indication of the bottom of the hole.

The bottom orientator 146 is operated by the apparatus 100, and in particular the core face profile device 120, tagging the bottom of the borehole. The operation of the bottom orientator 146, the latch body 128 and the anchor 130 are described in detail in Applicant's above referenced applications WO 03/038232 and WO 2005/078232. Nevertheless a brief description of the operation of these components is provided below with particular reference to Figures 4 and 5.

A shaft 152, which is provided with the key mark 142, extends axially through the races 150 and up into the lock housing 127 and latch body 128. The device 120 is coupled to a downhole end of the shaft 152. The lock housing 127 includes a tubular extension 156 which has seats 157 on its outer surface for respective latches 158 that are pivotally coupled to the latch body 128 and can extend through windows 160 formed in the latch body 128. A shroud 159 is attached to a downhole end of the lock housing 127 and covers the bottom orientator 146. A recess 161 is also formed in the lock housing 127 between the seats 157 and the shroud 159. A pretensioned spring 162 is disposed about an upper end of the shaft 152 within the extension 156 and biases the shaft to in an uphole direction. A further spring 164 is held in a cavity between the latch body 128 and the extension 156 and acts to bias the extension 156 and thus the lock housing 127 in a downhole direction.

Another spring 166 acts between the latch body 128 and an anchor sleeve 168 of the anchor 130 biasing the sleeve 168 toward a shoulder 170 formed about an anchor body 172 of the anchor 130. A plurality of anchor balls 174 are retained within the anchor sleeve 168. The anchor balls

174 roll along an outer surface 176 of the anchor body 172. When the anchor sleeve 168 is butted against the shoulder 170 by the spring 166, the balls 174 extend radially beyond the anchor sleeve 168. In this position, the anchor balls 168 are held on a constant outer diameter portion 178 of the anchor body 172.

Moving in a downhole direction from the portion 176 the outer circumference of the outer body 172 is formed with a tapered portion 180 that leads to a circumferential recess 182. The anchor body 172 also has, at its down downhole end, a portion 184 of a first constant inner diameter, then a contiguous tapered portion 186 that has an increasing inner diameter, and which then leads to a further portion 188 having a constant inner diameter greater than the inner diameter of the portion 184.

A trigger seat 190 is attached to a uphole end of the shaft 152 and a plurality of trigger balls 192 are each seated partially in a circumferential groove 194 formed in the trigger seat 190 and in holes 196 formed in an uphole end of the extension 156.

The apparatus 100 is loaded into a downhole end of a core tube 12 by first inserting the end provided with the tool 10. Eventually the latch dogs 158 abut a downhole end of the core tube 12 preventing further insertion of a tool 100. During the insertion, the anchor body 168 slides axially away from the shoulder 170 so that the anchor balls 174 roll along the tapered portion 180 and thus move radially inward. Once insertion of the apparatus 100 has been ceased by abutment of the latches 158 with the downhole end of the core tube, the spring 166 pushes the sleeve 168 in a uphole direction causing the anchor balls 174 to commence to ride up the tapered length 180 to a position where they extend radially outward from the sleeve 168 to an extent where they bear against an inner

surface of the core tube 12. This effectively locks the apparatus 100 to the core tube 12 preventing it from falling out. The core tube 12 is then lowered into a core drill 193 via a conventional backend and wire line or other insertion method, with the core drill being suspended above the toe of the borehole. With the core tube correctly seated within the core drill, the core face profile device 120 extends from the shroud 159 and a drill bit 195 coupled to a downhole end of the core drill 193. During this time, the orientation balls 148 are free to roll within their races 150.

The core drill is then lowered onto the toe of the hole resulting in the pins 136 sliding axially within the cylindrical body 132 to provide a profile of the toe of the hole.

As the core drill is further lowered, prior to the commencement of drilling, an end of the shroud 59 will eventually be brought into contact with the toe of the hole. Now, further lowering of the core drill results in the extension 156 sliding axially inward relative to the latch body 128 in a uphole direction compressing the spring 164. Eventually, the trigger balls 192 will roll outwardly along the tapered portion 186 to the portion 188 of the anchor body 172. When this occurs, the trigger balls 192 are able to move outwards in a radial direction and disengage from the groove 194 in the trigger seat 190. This releases the spring 162 allowing it to push the trigger seat 190 and thus the shaft 152 in an uphole direction relative to the extension 156. This results in a clamping of the orientation balls 148 within their races 150.

Continued lowering of the core drill onto the toe of the hole results in the seats 157 sliding from under the latches 158 so that the recess 161 underlies the latches

58. The latches 158 are now free to rotate inwardly thereby disengaging the apparatus 100 from the downhole end of the core tube 12.

The axial motion of the shaft 152 may be used to activate a switch such as, but not limited to, a microswitch, a Hall Effect switch, an optical switch or a pressure switch, which may be considered as forming part of the trigger system, to provide a trigger signal for the electronic orientation device 20. The electronic orientation device 20 can then log data relating to the orientation of a tool 10, the borehole in which it resides, and/or the core 112. The logging of information by the electronic device 20 may occur at a predetermined frequency for a predetermined period of time. For example the electronic orientation device/system 20 may log orientation data every 10 seconds for a two minute period after receipt of the initial trigger signal.

The electronic orientation device 20 may be arranged so that the logging of indications of orientation occur only when trigger signals are received from both motion of shaft 152 and at least one other sensor or transducer of the trigger system 24.

The indication of orientation provided by the core face profile device 120 and bottom orientator 146 can be transferred to the core 112 in a manner described in Applicant's above referenced Australian patent application no. 2006901550 using template 198 as depicted in Figure 7. Template 198 comprises a pair of parallel lines 200 for location on opposites sides of the orientation balls 148, and a pointer line 202 that extends parallel with an centrally between the tram lines 200. An elongated slot 204 is cut in the template 198 and has one edge 206 in alignment with the pointer line 202. The slot 204 extends over the scale 138 on the body 132 as well as over a

portion of the core sample 112. An operator can use a marker such as a pen or pencil to draw line segments 208a along the edge 206 from the body 132 across the scale 138 and 208b along the core 112. Indication of orientation logged by the electronic orientation device 20 may be obtained and marked on the core 112 in the same manner as described in Applicant's above referenced Australian application no. 2006902873.

The provision of both the tool 10 and the mechanical orientation device 146, as depicted in Fig.4, also enables auditing of the apparatus 100 to provide a degree of confidence in the orientation data obtained therefrom. This arises because embodiments where there is both the electronic orientation device 20 and one or more mechanical orientation devices 146, a comparison can be made between the same indications of orientation obtained from each of the devices. For example if bottom of hole indications provided by the separate devices are within a acceptable tolerance range (e.g. up to 5°) a high degree of confidence is provided that each of the devices 20 and 146 is providing reliable indications of orientation. However, if the devices give indications that differ more than an acceptable range, potential errors can be flagged on site to enable corrective action.

The combination of the core tube 12 and the core orientation tool 10 forming the apparatuses shown in Figures 3-6 comprise what is believed to be a unique core retrieval system in that the electronic orientation device 20 is, at least at the time of deployment, located at a downhole or front end of the core tube 12. More particularly, as will be appreciated from the above description, the apparatus 100 being at the front or down hole end of the core tube 12 is physically close to the core sample 112 at the time, or one of the times, at which the electronic orientation device 14 logs orientation data

of the tool 100. It is believed that this may give rise to higher accuracy in the orientation data recorded than other systems in which electronic orientation devices are located at a backend of the inner core tube, i.e. between an uphole end of the inner core tube and an overshot. In this regard, inner core tubes typically come in lengths of three or six metres.

It is envisaged that various embodiments of the tool 10 may perform self checks and provide users with information regarding the status of the tool 10. Status messages may include one or a combination of low battery power, communications error, system faults. The tool 10 may also collect and process data so as to provide users with a measure of the accuracy and reliability of the recorded orientation data. The data collected by the tool 10 to provide orientation information may be analysed using statistical measures of its accuracy. Log data may be analysed to identify the presence of any movement during the logging of orientation data. The direction of motion may also be determined and provided to a user. These self checks may be beneficial to identify surface requirements. In particular the indication of movement during logging may be beneficial in identifying improper operation of the tool 10 and thus flag the need for training or retraining of operators.

For example one can analyze data from the sensors to determine whether the core drill was rotating and/ subject to excessive vibration at the time of a core break. Such events, particularly the rotation, will decrease the reliability of the orientation data. The tool 10 would typically comprise three accelerometers to provide acceleration data about the X, Y and Z axes respectively. Rotation of the core drill at the time of the core break would be indicated by readings from these accelerometers.

More particularly the tool 10 may provide the operator with information regarding the proper operation of its components parts and systems. If a component or system fails the tool 10 could report the failure to the operator via the handheld control unit. If the failure occurs or is detected while the tool 10 is down a bore hole it can be reported to the operator via the handheld control unit ounce the tool has been recovered to the surface.

Further to the above operation the tool 10 could also be capable of performing a complete self check that verifies the correct operation of the entire system. This self diagnostics could be run on demand by an operator or automatically when the operator is preparing the tool for a core run (being run down a bore-hole to perform its function). In this way a faulty tool would not be used for a core run and result in a failed orientation.

The tool 10 may also be able to provide information to the operator regarding the certainty of a provided orientation measure. The certainty of a orientation measure can be determined by analysing the tools sensor input before during and after the orientation measure is made. When analysed the sensor data may reveal that there was an unwanted environmental condition present when the orientation measure was made. The unwanted environmental condition could be motion in the form of a linear movement, rotation or vibration. It could also be some other environmental condition such as a high or low temperature. The results of the analyses could be reported to the operator in one or a combination of the following ways:

1. By providing an indication of the source of unwanted environmental condition.

2. By associating the unwanted environmental condition to a known down-hole event that should not have occurred and providing the event to the operator.

3. By providing a calculated measure of the orientations certainty from the analysed sensor data. For example a scale of 1 to 5 could be employed where 1 is a certain orientation and 5 is a very uncertain orientation (failed). The certainty of orientations could then be provided using this scale.

The information provided by the tool in the above ways will be useful in identifying procedural errors made by the operators of the tool. For example if the core drill was spinning when the orientation was measured the tool 10 would report that the orientation is uncertain because rotation was detected during the orientation. It could also report that the likely cause of the rotation was that the core drill was spinning. In future the operator will know to ensure that the core drill is not spinning when the orientation is being measured. Similarly if the core drill was being raised or lowered when the orientation was measured the tool 10 could provide a relevant report to the operator.

By providing feedback regarding device faults and the certainty of the orientations when something goes wrong the operator will be fully informed as to the cause. Thus operator error can be discerned from tool failure/error. These reports can also be made available to supervisors or managers via the hand held control device or when the data is exported to an external memory device or laptop to assist them in maintaining equipment or attending to training issues.

Now that various embodiments of the present invention have been described in detail it will be apparent to those skilled in the relevant arts that numerous modifications and variations may be made without departing from the basic inventive concepts. For example, a mechanical orientation device 146 is described which utilises three orientation balls 148. However in an alternate variation,

this orientation device may comprise only a single orientation ball. In addition or alternately, the mechanical orientation device may include a washer that is indented with a mark representative of the location of the bottom of the hole such as described in Applicant's international publication no. WO 03/038232. Embodiments of the invention may also include in addition or as an alternate to the mechanical orientator 146 a mechanical inclinometer an example of which is described in Applicant's above referenced international publication no. WO 03/038232.

As an alternative to the Van Ruth (ie pin type) face orientator 120, core face orientation may be obtained by other devices including, marker pencils and scribes, optical or electromagnetic imaging and distance measuring devices. The logging of azimuth can be achieved using any known electronic system when measured by the electronic orientation device 20, or any known mechanical system when measured by a mechanical orientation device 146. These include for example the use of magnetometers to sense magnetic direction when used in conjunction with non-magnetic drilling equipment or if attached in a position outside the drill string to avoid magnetic interference. Azimuth may also be recorded using gyroscope type sensors to measure inertial change in position from a known reference point; or by use of a gyrocompass or north seeking gyroscope type sensor.

All such modifications and variations together with others that would be obvious to a person of ordinary skill in the art are deemed to be within the scope of the present invention the nature of which is to be determined from the above description, and the appended claims.

The claims defining the invention are as follows:

1. A core orientation tool for providing an indication of *in situ* orientation of a core sample extracted from a borehole by a core drill the tool comprising:

an electronic orientation system coupled with the core drill, the electronic orientation system configured, upon receiving a trigger signal, to log one or more first indications of orientation of the tool; and,

a trigger system that provides the trigger signal upon detecting one or more downhole events associated with operation of the core drill.

2. A core orientation tool for providing an indication of *in situ* orientation of a core sample extracted from a borehole by a core drill the tool comprising:

an electronic orientation system coupled with the core drill, the electronic orientation system configured, upon receiving a trigger signal, to log one or more first indications of orientation of the tool; and,
a trigger system that provides the trigger signal upon one or both of (a) detecting one or more downhole events associated with operation of the core drill, and (b) effluxion of time.

3. A core orientation tool for providing an indication of *in situ* orientation of a core sample extracted from a borehole by a core drill the tool comprising:

an electronic orientation system coupled with the core drill, the electronic orientation system configured to log one or more first indications of orientation of the tool; and,

a trigger system that provides a trigger signal upon detecting one or more downhole events associated with operation of the core drill; and,
wherein tool is configured to associate the one or more first indications of orientation with the trigger signal.

4. The core orientation tool according to any one of claims 1-3 wherein trigger signal is one of a plurality of trigger signals provided by the trigger system.

5. The core orientation tool according to claim 4 wherein the tool is configured to log different first indications of orientation upon receipt of different trigger signals.

6. The tool according to any one of claims 1-5 wherein the one or more downhole events comprise respective physical events arising from motion of the tool or the drill in the borehole.

7. The tool according to claim 6 wherein the motion comprise one or a combination of:

(a) motion in an uphole direction;

(b) a change in motion from motion having a linear component in a downhole direction to motion having no linear component;

(c) a change in motion from motion in a downhole direction to motion in an uphole direction;

(d) a change in motion from no linear motion to motion in an uphole direction;

(e) a change in characteristics of vibration motion on the tool or drill arising from the cessation or commencement of drilling;

(f) a change in speed of linear motion of the tool;

(g) any change in velocity (speed and/or direction of movement); and,

(h) a change in the rate or direction of rotation around the tool's longitudinal, lateral or normal axis.

8. The tool according to any one of claims 1-7 wherein the trigger system is configured to provide the trigger signal upon detecting a predetermined event or sequence of downhole events.

9. The tool according to claim 8 wherein the sequence of downhole events comprise a cessation of drilling followed by motion of the tool in an uphole direction.

10. The tool according to claim 9 wherein the sequence of downhole events further comprise commencement of drilling prior to the cessation of drilling.

11. The tool according to claim 10 wherein the sequence of downhole events further comprise one or more of:

(a) detecting contact of a backend assembly to which the tool is coupled hitting a landing ring in the core drill;

(b) detecting the backend assembly hitting a water table in a drilling operation where the drill is operated in the borehole below the water table;

(c) detecting release of the backend assembly from a wire line when initially inserting a core tube into the core drill;

(d) detecting the tool or core drill tagging a toe of the bore hole;

(e) an overshot hitting and latching onto the backend assembly;

(f) retrieval of the backend assembly from the drill hole; and,

(g) a change in the flow of fluid through or around the backend assembly.

12. The tool according to any one of claims 1-11 wherein the electronic orientation system further comprises an electronic azimuth measuring device, wherein the electronic azimuth measuring device operates to log azimuth upon receiving the trigger signal.

13. The tool according to claim 12 wherein the electronic azimuth measuring device is configured to operate in an idle state prior to receipt of the trigger signal.

14. The tool according to claim 13 wherein the electronic azimuth measuring device comprises an electronic gyroscope.

15. A core retrieval system for a core drill comprising:

a core tube having an uphole end and a downhole end, the downhole end provided with an opening for receiving a core sample cut by the core drill; and,

a core orientation tool in accordance with any one of claims 1-14, wherein the core orientation tool is coupled to the core tube at a location uphole of the downhole end of the core tube.

16. The core retrieval system according to claim 15 further comprising a backend assembly coupled to the uphole end of the core tube and wherein the core orientation tool is attached to the backend assembly uphole of the uphole end of the core tube.

17. A method of logging *in situ* orientation of a core sample extracted from the ground by a core drill comprising:

coupling an electronic core orientation device in a known spatial relationship to a core sample cut by the core drill;

configuring the electronic core orientation device to log one or more indications of orientation of the device upon receipt of a trigger signal; and,

providing the trigger signal upon detecting one or more downhole events associated with the operation of the core drill.

18. The method according to claim 17 wherein the downhole events are indicative of a, or an imminent, core break.

19. The method according to claim 17 or 18 wherein detecting of the one or more downhole events comprises detecting an uphole motion of the device.

20. The method according to claim 19 wherein the detecting of the downhole event comprises detecting a cessation of

drilling prior to detecting the uphole motion of the device.

21. The method according to claim 20 wherein the detecting further comprises detecting commencement of drilling prior to detecting cessation of drilling.

22. The method according to claim 21 wherein the detecting comprise detecting a cessation of downhole movement of the device prior to detecting the commencement of drilling.

23. The method according to any one of claims 17- 22 wherein the configuring comprises configuring the electronic core orientation device to determine azimuth.

24. The method according to claim 23 further comprising withdrawing the tool after the trigger system provides the trigger system and operating the electronic core orientation device to track changes in orientation until the tool reaches a collar of the borehole.

25. A core orientation apparatus for providing an indication of orientation of a core sample extracted from a borehole by a core drill the apparatus comprising:

a core orientation tool according to any one of claims 1-14 and,

one or more secondary orientation devices which provide one or more second indications of orientation of the core or borehole, wherein the electronic orientation device is in a known rotational position relative to the one or more secondary orientation devices.

26. The apparatus according to claim 25 wherein the secondary devices comprise one or both of (a) a core face orientation device which records orientation of an uphole face of a core sample; and (b) a bottom of hole recording device.

27. The apparatus according to claim 25 or 26, wherein the tool comprises a body having a downhole end and an uphole end, wherein a the one or more secondary orientation devices are located downhole of the body and the electronic orientation device is located between the secondary orientation devices and the downhole end of the body.

28. The apparatus according to claim 25 or 26, wherein the tool comprises a body having a downhole end and an uphole end, wherein the one or more secondary orientation devices are located downhole of the body and the electronic orientation device is located uphole of the body.

29. The apparatus according to claim 27 or 28, wherein the body is provided with a positional reference for the first and second indications of orientation, and one or more keys for keying the electronic orientation device and the one or more secondary orientation devices to the position reference.

30. A core retrieval system for a core drill comprising:

an inner core tube having an uphole end and an opposite downhole end provided with an opening for receiving a core cut by the core drill; and,

a core orientation tool coupled to the inner core barrel and movable inside the inner core tube in an uphole direction by abutment with the core, wherein the core orientation tool accords with any one of claims 1-14.

31. The core orientation tool according to any one of claims 1-14 wherein the tool is configured to analyse outputs from sensors and transducers in the trigger system that detect the downhole events, to verify correct operation of the tool.

32. The core orientation tool according to claim 31

wherein the tool is configured to analyse outputs from sensors and transducers in the trigger system that detect the downhole events to verify that the core drill was stationary when a core break operation was performed.

33. The method according to any one of claims 17-24 comprising analyzing outputs from sensors and transducers in the trigger system that detect the downhole events, to verify correct operation of the tool.

34. The method according to claim 33 wherein the analyzing comprises analyzing the outputs to verify the core drill was stationary at when a core break operation occurred.

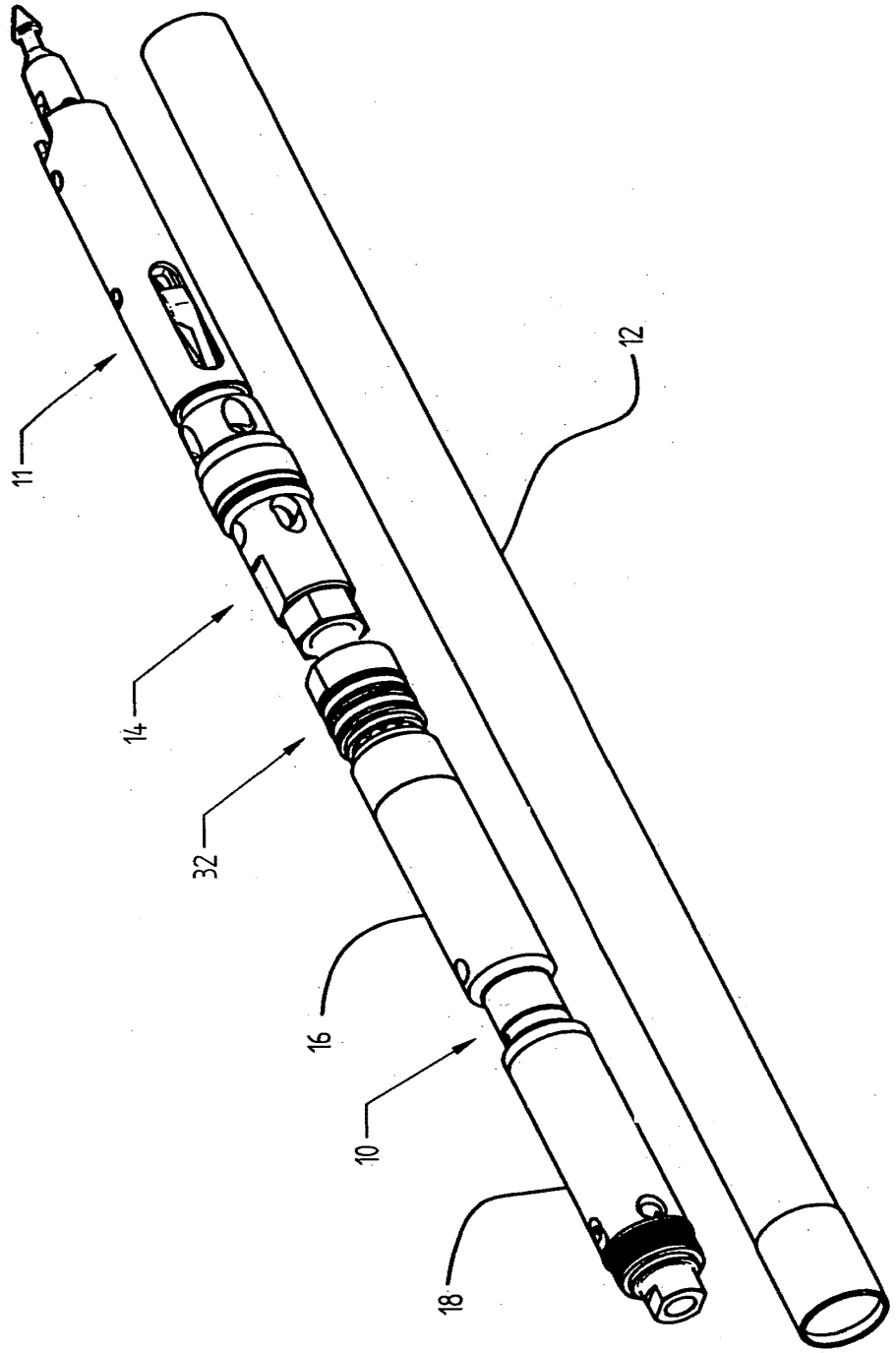


Figure 1

Figure 2

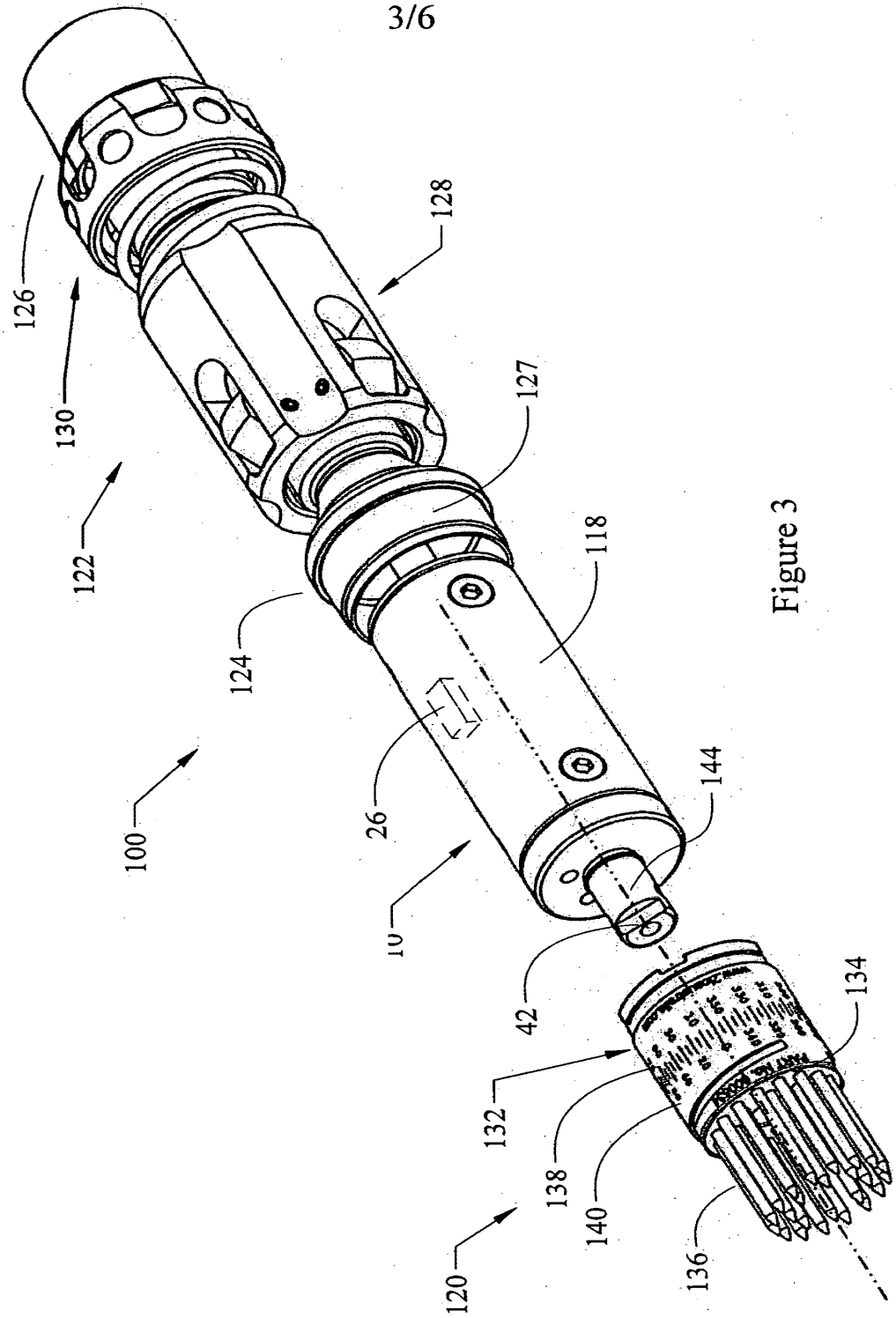

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Figure 3

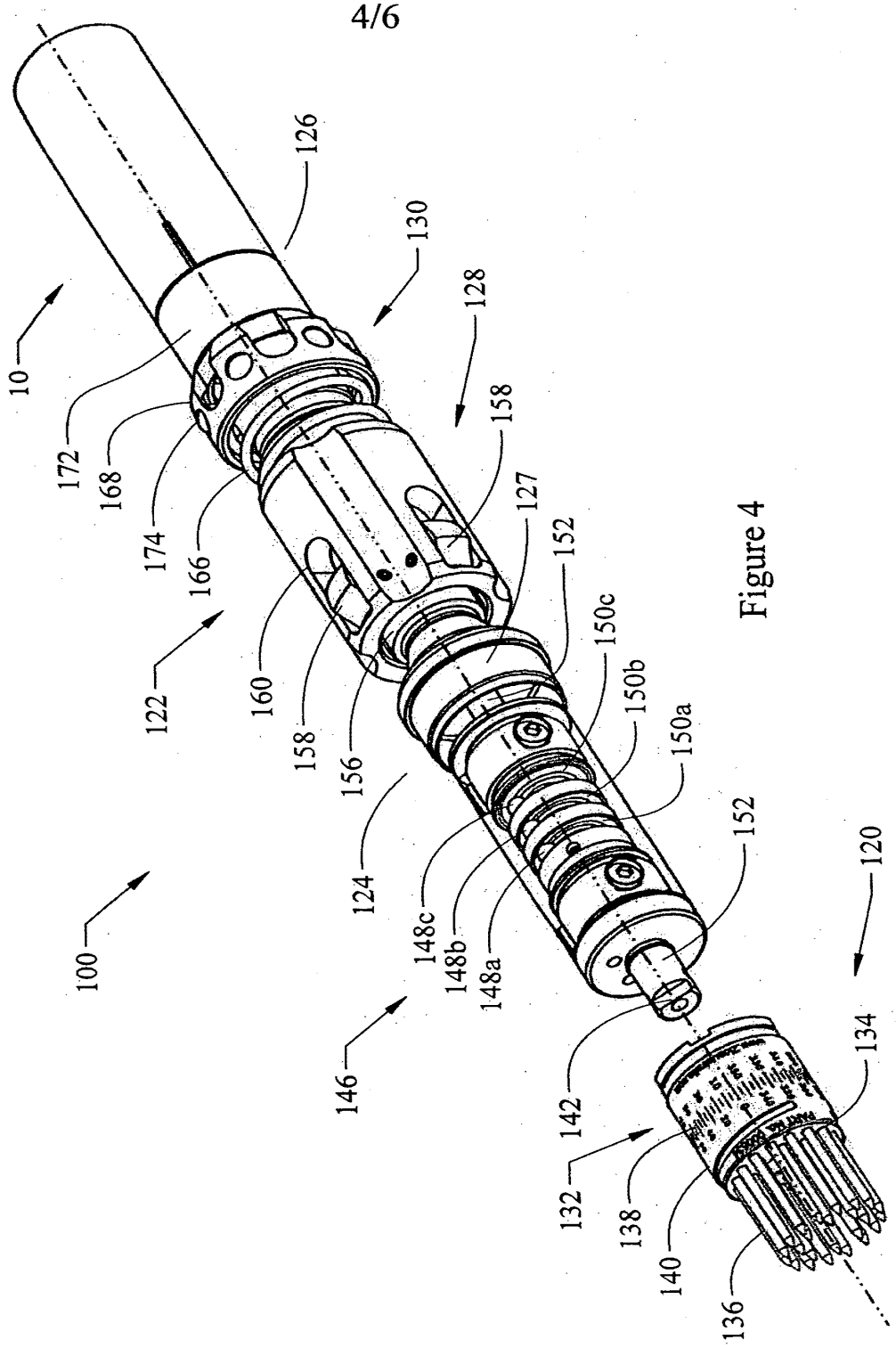

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Figure 4

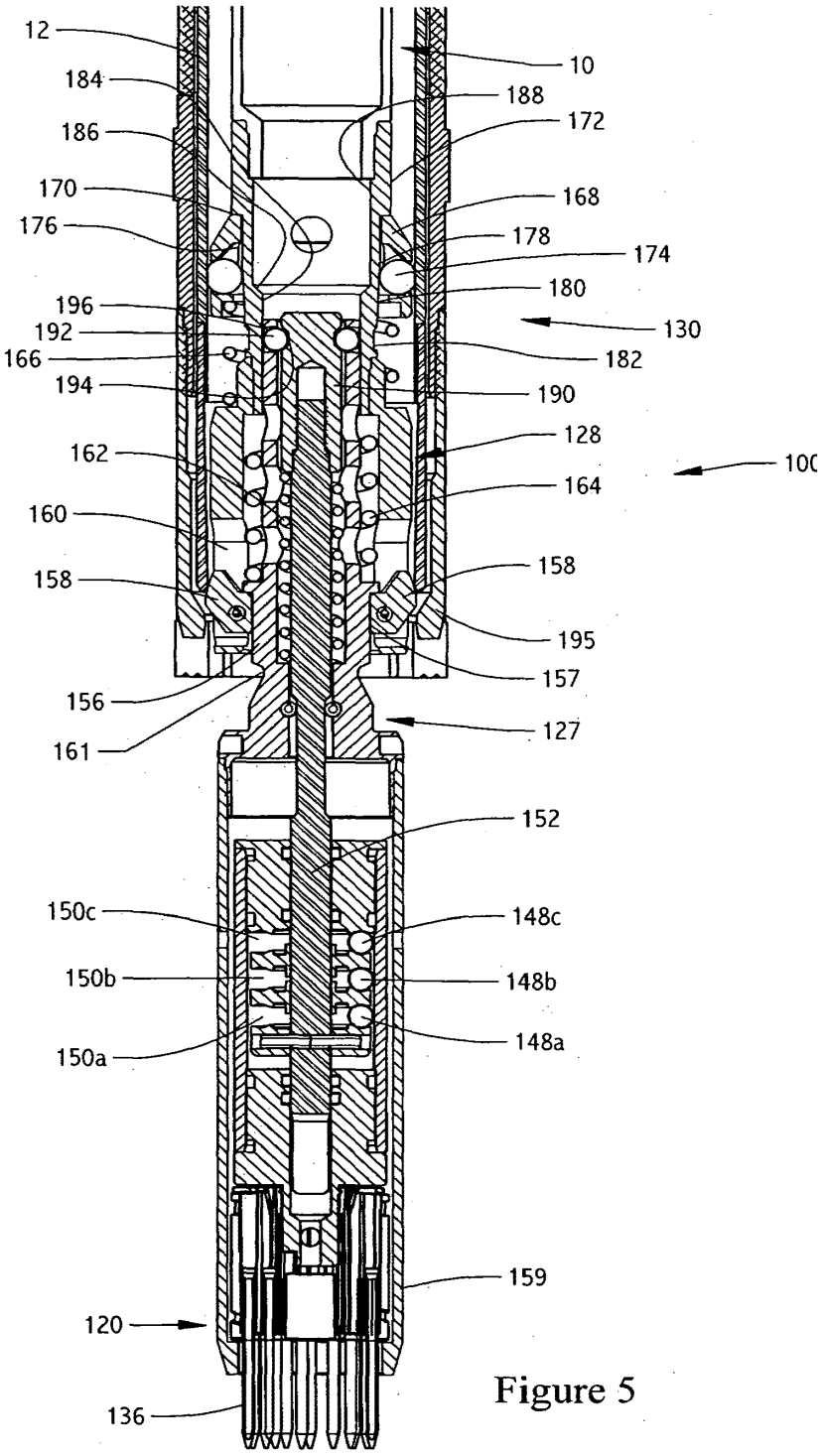

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Figure 5

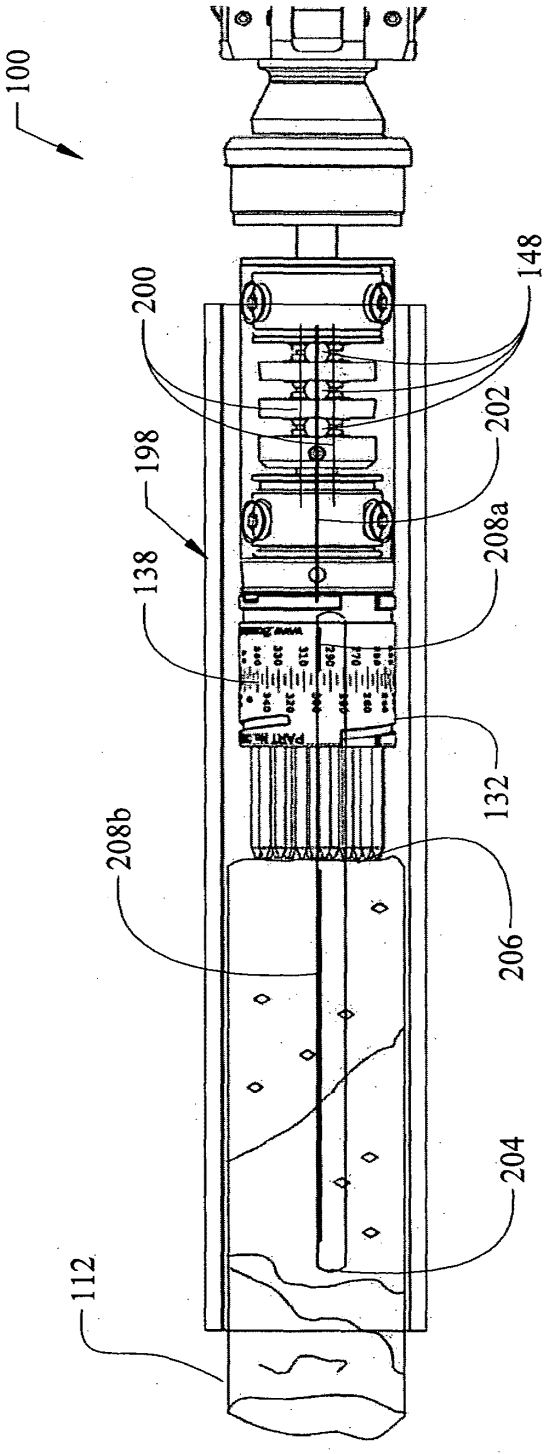


Figure 6

INTERNATIONAL SEARCH REPORT

International application No.
PCT/AU2008/000395

A. CLASSIFICATION OF SUBJECT MATTER

Int. Cl. ***E21B 25/16*** (2006.01) ***E21B 49/02*** (2006.01)

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)

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

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
Dwpi: E21B 25/16, 49/02 with keywords (trigger+, sens+, signal+, azimuth+, gyroscop+, generat+, activate+, detect+, electronic+)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2006/024111 A1 (AUSTRALIAN MUD COMPANY LTD) 9 March 2006 Page 10, line 18 – page 24, line 25	1-10, 12-25, 30 and 31-34
X	WO 2006/058377 A1 (CORETRACK PTY LTD) 8 June 2006 Page 3, line 9 – page 5, line 15; claims 1-9 and Figures 1-4	1-10, 12-25, 30 and 31-34
X	Derwent Abstract Accession No. 97-242837/22, Class X25, JP 09078975 A (NIPPON SHINKO KK) 25 March 1997	1-10, 12-25, 30 and 31-34
A	US 6006844 (PUYMBROECK et al) 28 December 1999 The whole document	1-34

[X] Further documents are listed in the continuation of Box C [X] 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	Date of mailing of the international search report
05 May 2008	17 MAY 2008
Name and mailing address of the ISA/AU AUSTRALIAN PATENT OFFICE PO BOX 200, WODEN ACT 2606, AUSTRALIA E-mail address: pct@ipaustralia.gov.au Facsimile No. +61 2 6283 7999	Authorized officer **LEOPOLD FILIPOVIC** AUSTRALIAN PATENT OFFICE (ISO 9001 Quality Certified Service) Telephone No : (02) 6283 2105

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/AU2008/000395

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	CA 2456506 A1 (SCOTT) 3 January 2005 The whole document	1-34
A	WO 2005/085584 A1 (2iC AUSTRALIA PTY LTD) 15 September 2005 The whole document	1-34

Form PCT/ISA/210 (continuation of second sheet) (April 2007)

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.
PCT/AU2008/000395

This Annex lists the known "A" publication level patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent Document Cited in Search Report		Patent Family Member					
WO	2006024111	AU	2005256104	AU	2006100113	CA	2559030
		US	2007282533				
WO	2006058377	AU	2005312340	EP	1817480		
JP	9078975						
US	6006844	BE	1011414	CA	2158903	DE	19745947
		GB	2293395	GB	2318372	NO	953755
		NO	974786	US	5568838		
CA	2456506						
WO	2005085584	AU	2005219460	CA	2559085		

Due to data integration issues this family listing may not include 10 digit Australian applications filed since May 2001.

END OF ANNEX

(12) UK Patent Application (19) GB (11) 2 243 173 (13) A

(43) Date of A publication 23.10.1991

(21) Application No 9106537.5

(22) Date of filing 27.03.1991

(30) Priority data
(31) 500148 (32) 27.03.1990 (33) US

(71) Applicant
Seafloors Engineers Inc

(Incorporated in the USA - Texas)

2500 Central Parkway, Suite M, Houston, Texas 77092, United States of America

(72) Inventors
Wayne B Ingram
Byron W Porter

(74) Agent and/or Address for Service
Kilburn and Strode
30 John Street, London, WC1N 2DD, United Kingdom

(51) INT CL[5]
E21B 25/00, E02D 1/00

(52) UK CL (Edition K)
E1F FHA FHA1 FHA2

(56) Documents cited
EP 0083141 A2 **US 4770030 A** **US 4601354 A**
US 4499956 A **US 4499955 A**

(58) Field of search
UK CL (Edition K) **E1F FHA**
INT CL[5] **E02D, E21B**

(54) Self-contained apparatus and method for determining the static and dynamic loading characteristics of a soil bed

(57) The invention comprises an apparatus and method for sampling and determining the dynamic loading characteristics of a soil bed. The apparatus is specially adapted to withstand the extreme pressures of deep water applications. In operation, a drill string presses a sample tube 23 into a soil bed at an uncontrolled rate resulting in a variable penetration rate. The apparatus has a self-contained data acquisition system that measures and records, as a function of time, the force exerted on the sampling apparatus and the depth of penetration as the drill string presses the sampling apparatus into the soil bed.

Data is provided that enables the user to determine the static soil characteristics (e.g., shear strength and stress-strain characteristics) and the dynamic loading characteristics of the soil bed. The apparatus captures a sample of the soil for laboratory analysis.

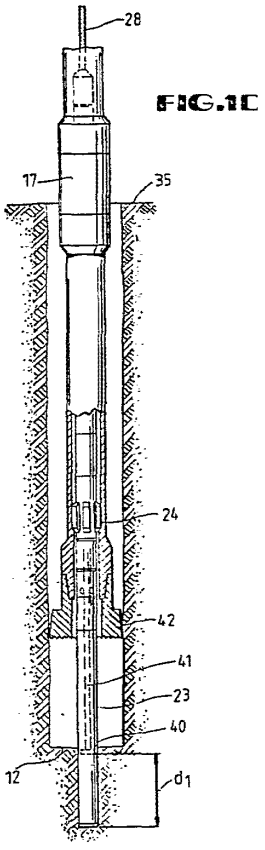


FIG.1C

At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

GB 2 243 173 A

FIG.1A

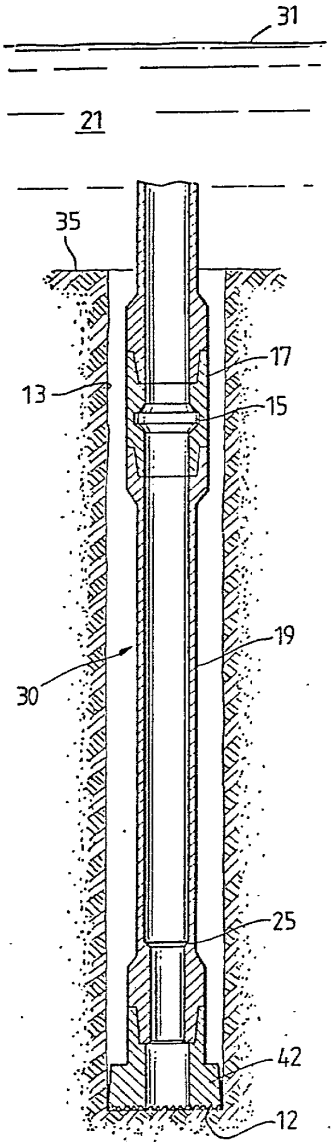


FIG.1B

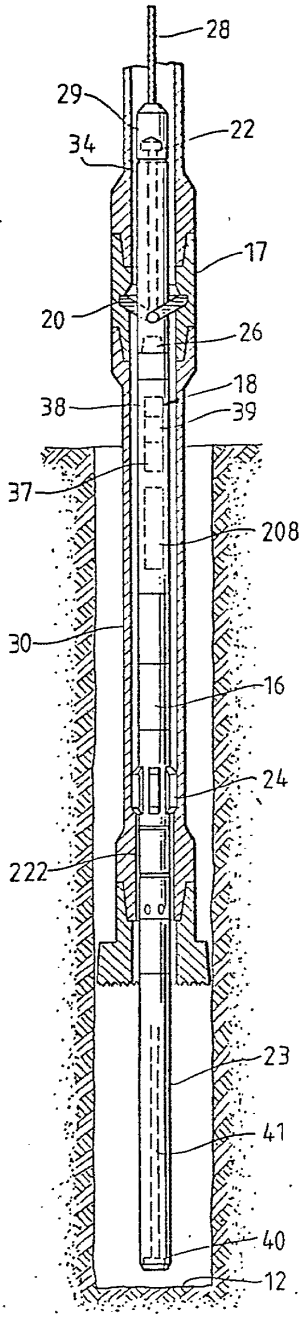


FIG.1C

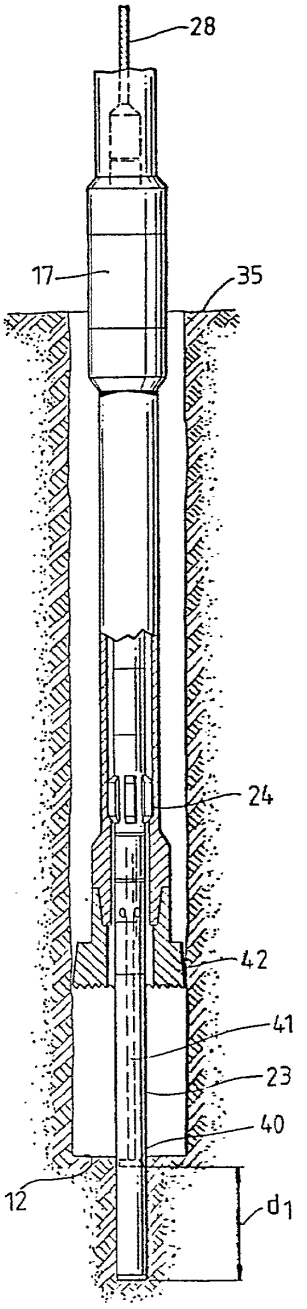


FIG.1D

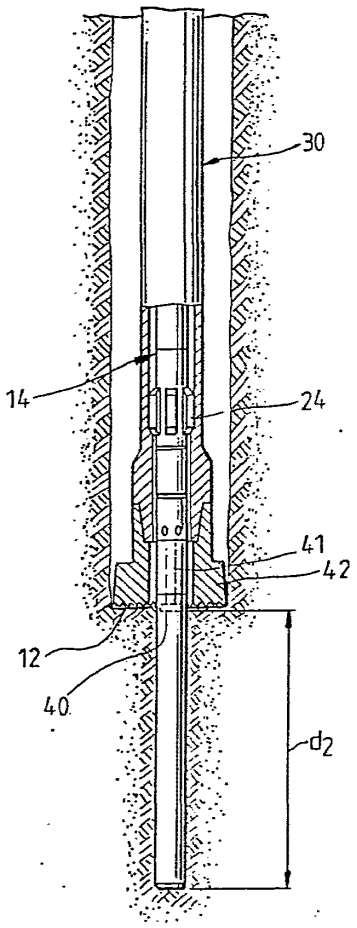
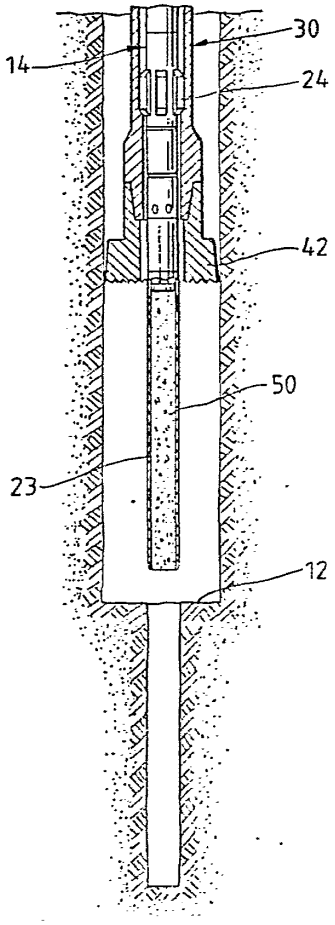


FIG.1E



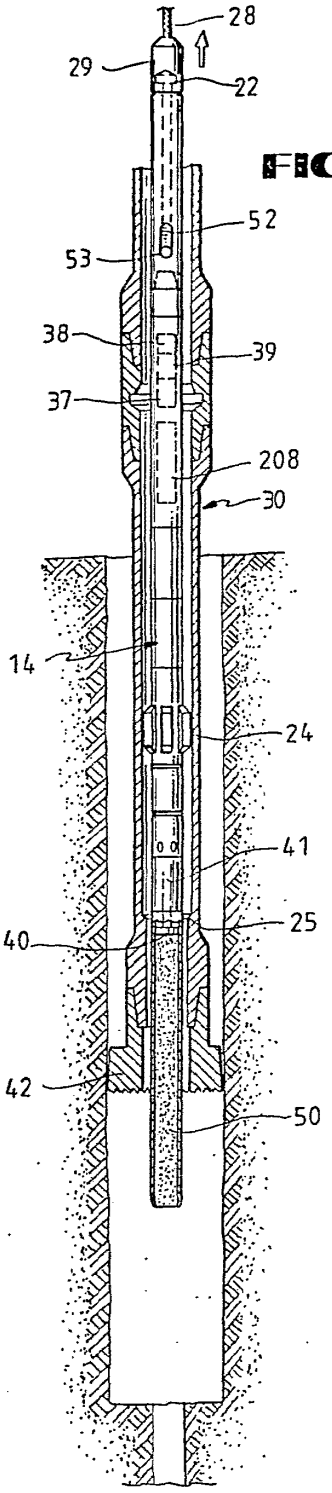

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FIG.1F

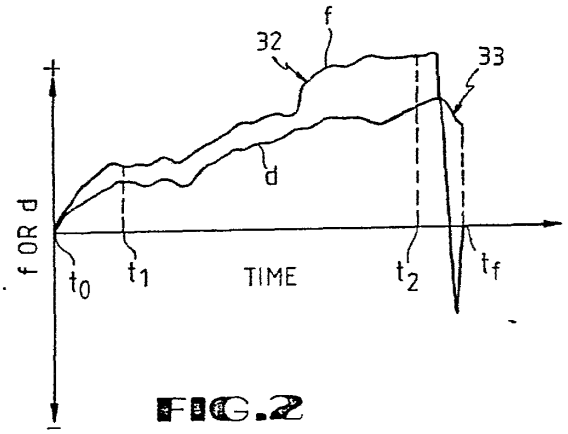

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f OR d
t_0
t_1
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FIG.2

FIG.3A

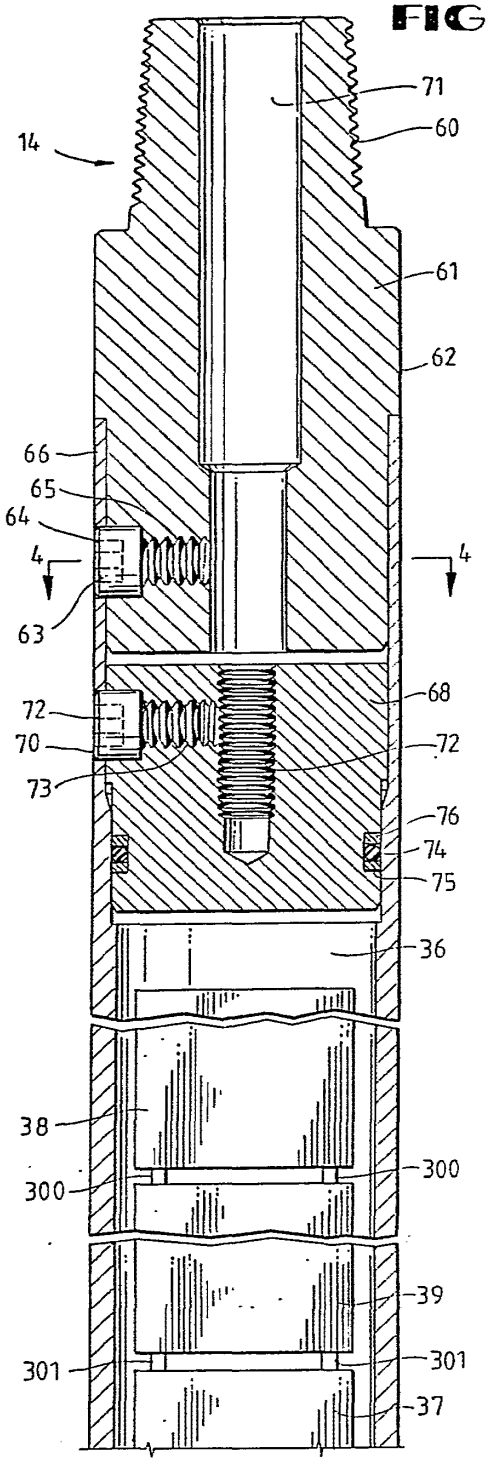

71
60
14
61
62
66
65
64
4
4
63
72
70
73
68
72
76
74
75
36
38
300
300
39
301
301
37

FIG.3B

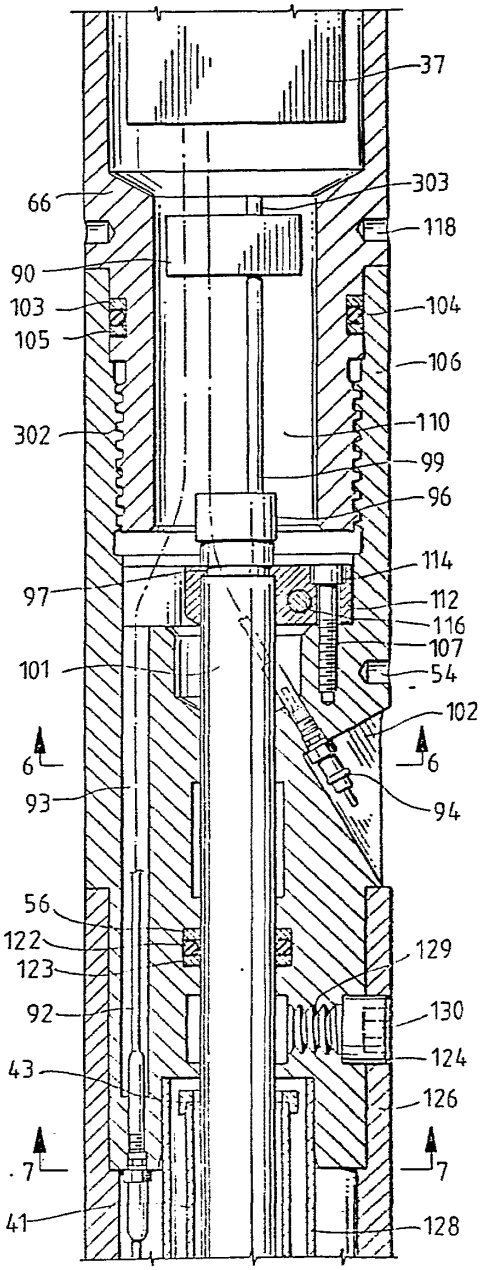

37
303
66
118
90
103
105
104
106
302
110
99
96
114
97
112
116
107
54
101
102
6
6
93
94
56
122
123
129
92
130
124
43
126
7
7
41
128

FIG.3C

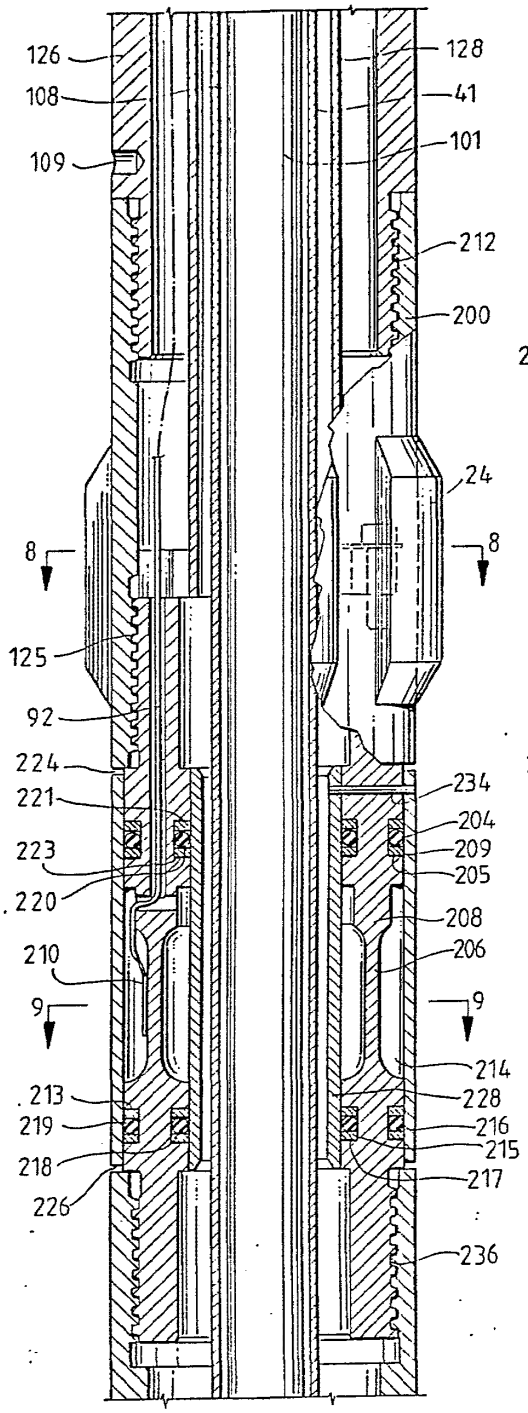

126
108
109
128
41
101
212
200
24
8
8
125
92
224
221
223
220
210
9
9
213
219
218
226
234
204
209
205
208
206
214
228
216
215
217
236

FIG.3D

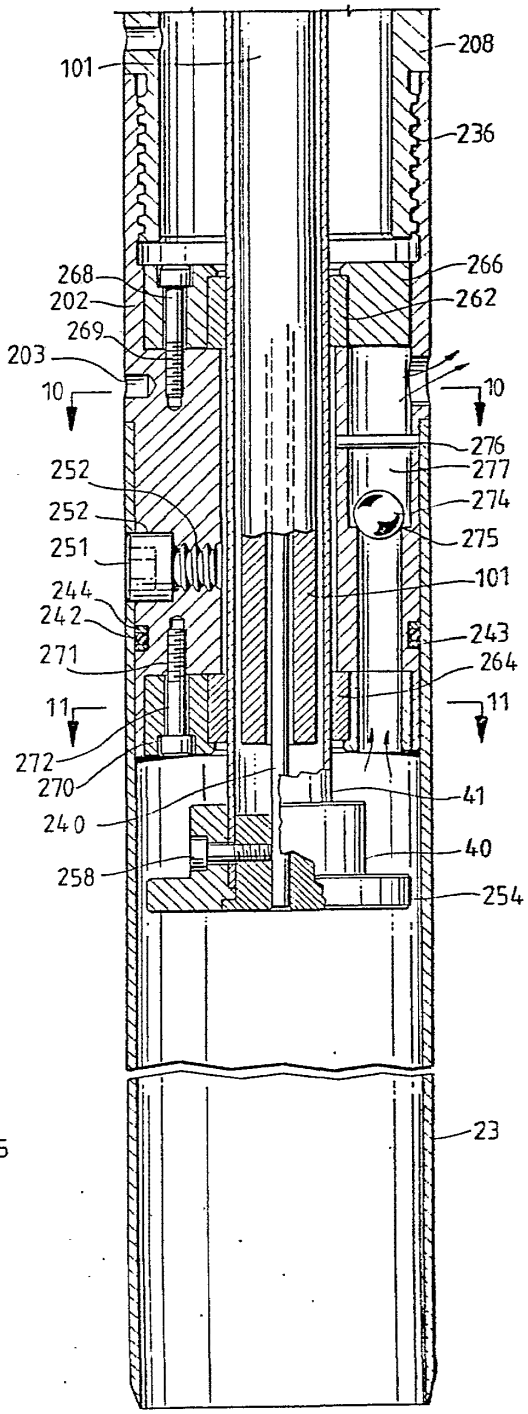

101
208
236
268
202
269
203
266
262
10
10
276
277
274
275
252
252
251
244
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271
101
243
264
11
11
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41
40
258
254
23

FIG.4

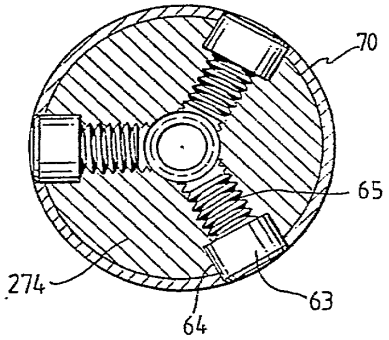
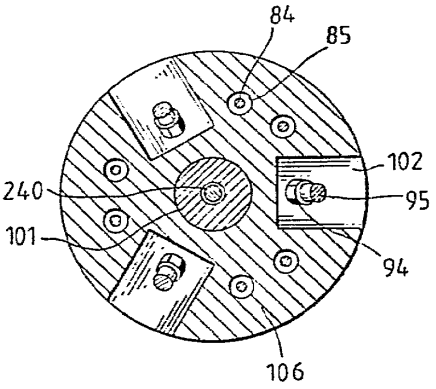


FIG.6



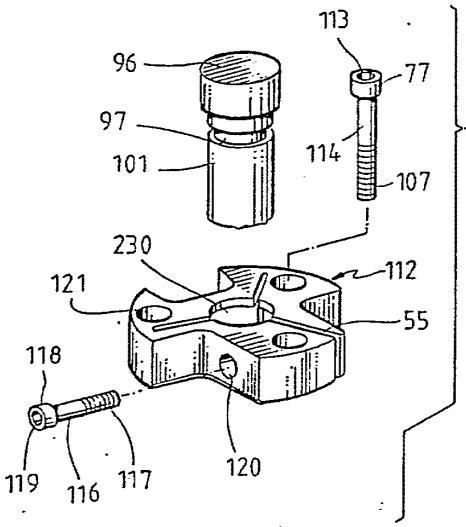


FIG.5

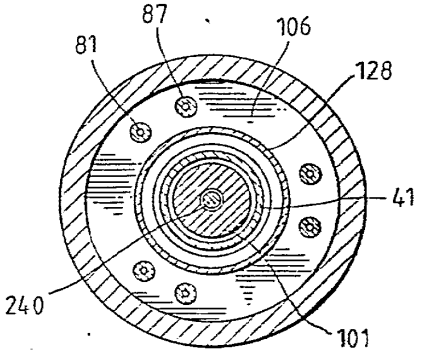


FIG.7

FIG.8

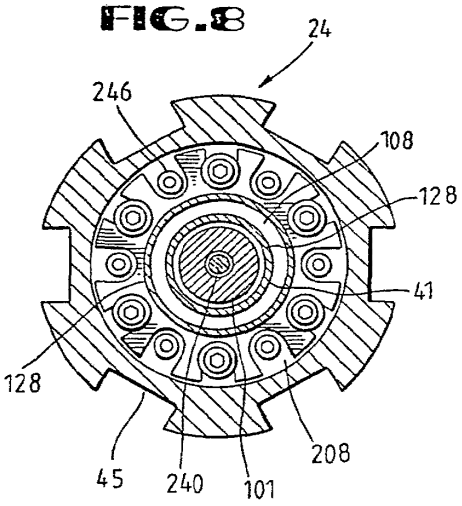
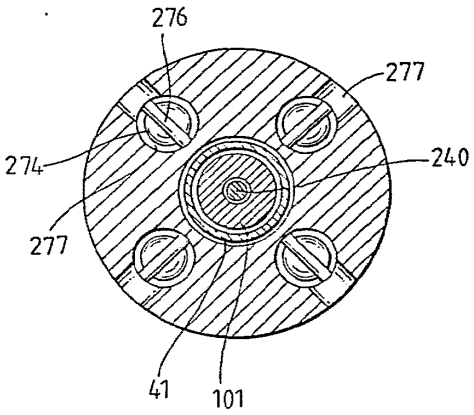


FIG.10



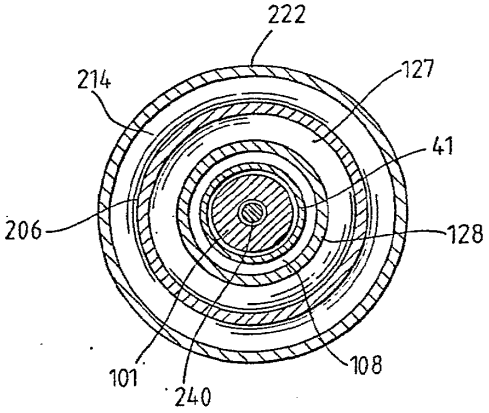


FIG.9

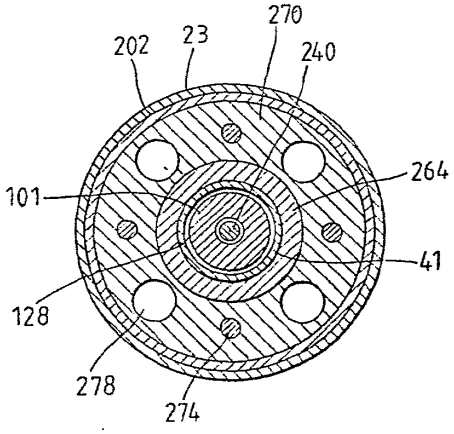


FIG.11

SELF-CONTAINED APPARATUS AND METHOD FOR DETERMINING THE STATIC AND DYNAMIC LOADING CHARACTERISTICS OF A SOIL BED

This invention relates generally to novel data gathering and sampling in connection with soil mechanics. More particularly, this invention concerns a method and apparatus for sampling and determining the dynamic loading characteristics of a soil bed, and more particularly, a method for measuring, as a function of time, the force and displacement on a soil sample as the apparatus presses into a soil bed at an uncontrolled rate resulting in a variable penetration rate. The apparatus may be used in connection with a sub-sea soil bed or a soil bed on land.

In the past, it has been common practice to extract soil samples and make laboratory measurements of data concerning the characteristics of a soil bed on the recovered samples. While some arrangements have exhibited at least a degree of utility in the gathering of data in connection with soil mechanics analysis, room for significant improvement remains.

The structural loading of soil has been a problem for many years, but these problems were not approached in an orderly manner until the advent of modern soil mechanics theory in the 1920's. The application of soil mechanics theory requires the collection of accurate data to evaluate certain soil parameters. The task of

gathering reliable data is of paramount importance in the satisfactory application of soil mechanics theory. This task becomes acutely more difficult when analyzing a soil bed that lies beneath a body of water.

As the world's oil supply dwindles and available land based drilling sites are exhausted, the need to construct offshore oil drilling platforms increases. The increased size and utilization of these offshore platforms magnifies the need for reliable data to evaluate the stability of sub-sea soil beds. Offshore platforms constructed on pilings driven into the soil bed under bodies of water proliferate in the Gulf of Mexico and along the continental shelf bordering the east and west coasts of the United States.

Data taken while sampling a soil bed helps determine the soil bed's ability to support the foundation of a structure. A foundation is only as stable as the soil bed that supports it. Accurate data collection concerning a soil bed is the first step in correctly evaluating the soil bed's ability to support a structural foundation. A stable foundation is fundamental to the stability of a structure. The need for accurate design data is paramount. A calculation based on erroneous data is a miscalculation that can produce disastrous results. A structure built upon a piling foundation, subjected to a sudden load from a wave surge or earthquake, can collapse, resulting in a loss of life and property.

The ability of a soil bed to support a structure's foundation is related to the rate a load is applied to the foundation. While a soil bed may adequately support a foundation during normal wave activity, or normal land based loading, the soil bed may not adequately support the foundation during a sudden surge in response to severe

wave action or an earthquake. An unexpected load applied suddenly to the foundation could topple the structure. Therefore, there is an important need to accurately predict the ability of a soil bed to support a structure, especially during the variable rate loading conditions experienced on land and at sea. Variable rate loading characteristics are referred to as the dynamic loading characteristics of the soil bed.

Present methods and apparatus for measuring the ability of a soil bed to support a structure are limited in several ways. First, there are no known methods or apparatus that measure the dynamic loading characteristics of a soil bed as a function of time. Moreover, present methods and apparatus utilize short displacement, cyclic, linear penetration techniques that penetrate a soil bed at a constant rate and do not measure the dynamic loading characteristics of the soil.

Known measuring systems are intolerant of a hostile sea state and require a benign sea state to obtain accurate data. Unless these methods and apparatus are used in smooth water conditions, motion compensation devices must be used to obtain accurate measurements.

Physical interface umbilicals from the surface are difficult to deploy and present a formidable, if not impossible, design challenge in deep sea applications. In addition the tremendous pressure exerted on equipment and instrumentation submerged in over five hundred fathoms of water presents a formidable design problem.

Isolating a monitoring system from extreme water pressure and from the corrosive action of the sub-sea environment is extremely difficult. These problems are exacerbated by the use of physical umbilicals.

The problems enumerated in the forgoing are not exhaustive but rather are among many which tend to impair the effectiveness of previously known soil sampling and data gathering systems. Other noteworthy problems may also exist; however, those presented above should be sufficient to demonstrate that soil sampling and data gathering systems appearing in the art have not been altogether satisfactory.

Recognizing the need for an improved soil sampling and data gathering system it is, therefore, a general object to provide a novel method and apparatus for determining the dynamic loading characteristics of a soil bed which are simple to construct and operate and which obviate the need for an umbilical between the apparatus and the surface.

Another object of the present invention is to provide a self-contained method and apparatus for determining dynamic loading characteristics of a soil bed by measuring a plurality of parameters associated therewith.

Yet another object of the present invention is to provide a method and apparatus for determining the dynamic loading characteristics of a soil bed, that can withstand the extreme pressures of deep water operations without leakage and remain isolated to neither contaminate nor be contaminated by the ocean environment.

A further object of the present invention is to provide a self-compensating method and apparatus for determining the dynamic loading characteristics of a under water soil bed that can be operated from a floating platform.

To attain these and other objectives, an apparatus for sampling a soil bed from the surface of the earth or the surface of a body of water is provided. The apparatus includes a housing adapted to attached to the bottom of a drill string. On land the housing may be attached directly to the drill string by removing the drill string from the well bore and attaching the housing to the bottom of the drill string in place of the drill bit. At sea the housing may be dropped down the drill string or lowered from a wire line within the drill string for transporting the apparatus from the surface of a body of water to a location adjacent the soil bed beneath the body of water. Additionally the apparatus includes a sub positioned in the drill string and adapted to receive the apparatus housing during sea-based operations, a sample tube extending below the housing for penetrating the soil bed, a means for attaching the housing to the bottom of the drill string, a selectively lockable means for use during sea-based operations to selectively lock the housing into the sub to enable the housing to transmit load between the drill string and the sample tube, a load detector within the housing adapted to generate a first signal corresponding to loading as a function of time on the sample tube, a movement detector within the housing adapted to generate a second signal corresponding to the upward displacement of a soil sample within the sample tube and a recorder within the housing adapted to record the first and second signals simultaneously.

The present invention is defined in the accompanying claims, both to apparatus for and a method of soil sampling, to which claims reference should now be made.

The present invention addresses the problems described above by providing a system for sampling a soil bed which is capable of operation from a floating or land-based platform. The system is further capable of pressing on a soil bed at a uncontrolled rate resulting in a variable penetration rate, and also retrieving a soil sample. The variable penetration rate is beneficial in providing insight into the dynamic loading characteristics of the soil bed.

The apparatus of the invention is self-contained. It may be attached directly to the bottom of a drill string or it may be dropped down the well bore or lowered on a wire line without removing the drilling apparatus. Consequently, samples may be obtained and retrieved from, say, a well bore without removing drilling apparatus from the bore. An instrument package may be deployed and retrieved from a well bore without removing drilling apparatus from the bore. The apparatus contains a data acquisition system that records various parameters, notably the soil penetration rate and the load required to affect penetration. Soil samples captured by the apparatus are retrievable raising the drill string or retrieving the housing by wire line, thus enabling the operator to keep the drilling apparatus in the well bore throughout the sampling.

The system of the invention is suitable for use with conventional drilling systems. The apparatus of the invention is insertable into a conventional drill string above a conventional drag bit or coring bit, i.e., a bit having a central passageway or opening. The apparatus of the invention may also be attached directly to the bottom of a drill string.

The apparatus of the invention also comprises an elongated housing, adapted at its upper end to releasably engage an overshot or the like for attachment to the lower end of a wire line. A plurality of dogs or the like are positioned near the upper end of the housing. The dogs engage recesses formed in the inner wall of the housing, and are designed to be retractable.

A sample tube, preferably cylindrical in shape, comprises or attaches to the lower end of the housing. The sample tube slides through the opening in the drill bit when the housing is locked into the drill line during sea-based operation. When the apparatus of the invention locks into position in the sub for sea-based operation, the sample tube protrudes below the bit by a selected amount, which in practice may measure about two feet or about sixty centimeters. Thus, as the sample tube presses into a soil bed, a sample of the soil enters the sample tube.

The housing portion of the apparatus generally will be an assembly of several components. A first such component, a load cell, positioned in the housing, couples to the top of the sample tube. The load cell measures the axial load imposed on the sample tube. There are many ways to measure such a load.

A second component of the housing is an instrument chamber or compartment. This component will normally contain a power pack, a data acquisition system and an electronics package. The instrument compartment may also contain an LVDT unit or other position measuring device for indicating the extent to which a core sample enters the sample tube. To activate the LVDT unit, a sample or core follower is preferably provided within the sample chamber. The core follower includes a piston immediately above a sample in the sample tube and a piston rod attached to the piston. As a soil sample enters the sample tube, the piston travels upward. The LVDT core rod attaches to the piston to provide a measurement of the sample length.

From these features of the invention, it becomes apparent that use of the invention provides a continuous record of the load acting to penetrate and withdraw a soil bed, as well as the extent of penetration. The invention also provides a soil sample which is retrievable from the surface of a body of water or from the surface of the earth.

An especially attractive feature of the invention is its ability to operate without motion compensation. Thus, movement of a floating vessel or platform from which the invention operates may vary the loading on the sample tube as well as its rate of penetration without degradation of the measurement data's accuracy. However, these are the same type of dynamic factors which affect the legs of platforms, pilings or other structural members which penetrate a soil bed. Hence, the dynamic data provided by the present invention provides a very useful insight into the dynamic performance to be expected of such structural members in a soil bed from which the data is obtained.

In accordance with the invention, the load data and the penetration data for a given soil sample are recorded with time as the sample tube presses into the soil. The resulting records are especially valuable in reflecting the uniformity of the soil.

The invention has particular application not only in offshore operations, but is also of great interest in land based operations. In addition to oil and gas drilling structures, the invention is useful in other offshore and land based structures such as, for example, bridges, towers, tall buildings, and the like. The dynamic characteristics are useful in the evaluation of soil properties for earthquake analysis.

In one aspect of the present invention, a method is provided for determining the dynamic loading characteristics of a soil bed by measuring the forces exerted on a self-contained, environmentally isolated data measurement and sampling apparatus. A sample tube presses into the soil bed at an uncontrolled rate resulting in a variable penetration rate. The data acquisition system measures and records the force, as a function of time, exerted on the sample tube during penetration and withdrawal. The data acquisition system measures and records the depth of penetration as a function of time. These measurements are used to determine the dynamic loading characteristics of the soil bed. The method includes a step whereby the sample tube captures a soil sample for laboratory analysis at the surface.

Soil parameters of primary interest are pile design parameters with an emphasis on open ended steel pipe piles which are used offshore. If a steel pipe pile and a steel sample tube are compared, they are of very similar proportions. It is therefore to be expected that the

parameters measured while pushing a sampling tube into a soil bed may be applied to driving a pile into the soil. The value of these measurements is accordingly apparent. With appropriate interpretation and modification, the measurements taken during sampling may be applied advantageously to pile design.

Additional objects, features and advantages of the present invention will become apparent with reference to the following detailed description of a preferred embodiment thereof in connection with the accompanying drawings, wherein like reference numerals have been applied to like elements, in which drawings :

Figure 1A is a schematic or conceptual drawing that shows a boring drilled to the desired depth in a soil bed using an open ended drag bit.

Figure 1B is a schematic or conceptual drawing of one embodiment of the apparatus of the invention as it is lowered into the drill string and latched into place. The sampling tube extends beneath the open drill bit at the end of the drill string.

Figure 1C is a schematic or conceptual drawing that shows a drill string pushing the sampling apparatus of the invention into the sub-sea soil bed.

Figure 1D is a schematic or conceptual drawing that shows the sampling apparatus of the invention after it is fully inserted into the soil bed to a depth d2.

Figure 1E is a schematic or conceptual drawing that shows the drill string as it withdraws the sampling apparatus to remove it from the soil bed.

Figure 1F is a schematic or conceptual drawing that shows the retrieval system as it attaches to the top end of the apparatus, unlatches the apparatus from the drill string and raises the apparatus to the surface.

Figure 2 is a graph that shows possible force and displacement curves, plotted as a function of time. Time

t1 corresponds to depth d1 in Figure 1C. Time t2 corresponds to depth d2 in figure 1D.

Figure 3A is a partial longitudinal section view that shows the top section of one embodiment of the apparatus of the invention. The apparatus is divided into four sections in Figures 3A-3D.

Figure 3B is a partial longitudinal section view that shows the second section of the apparatus.

Figure 3C is a partial longitudinal section view that shows the third section of the apparatus.

Figure 3D is a partial longitudinal section view that shows the fourth section of the apparatus.

Figure 4 is a view taken along section lines 4-4 of Figure 3A.

Figure 5 is an exploded view of a retaining clamp to hold the LVDT in place and to prevent the LVDT from being pushed into the instrument compartment by extreme water pressures at great depths under water.

Figure 6 is a view taken along section lines 6-6 of Figure 3B.

Figure 7 is a view taken along section lines 7-7 of Figure 3C.

Figure 8 is a view taken along section lines 8-8 of Figure 3C.

Figure 9 is a view taken along section lines 9-9 of Figure 3C and shows the load cell web. All the load is

transmitted through the load cell web. The outer sleeve of the load cell and the inner sleeve of the load cell are shown along with the piston sleeve, the LVDT and the LVDT core rod.

Figure 10 is a view taken along section lines 10-10 of Figure 3D and shows a fluid release orifice positioned at the top of each ball valve channel. The piston sleeve, the LVDT and the LVDT core rod are shown concentrically located in the apparatus housing.

Figure 11 is a view taken along section lines 11-11 of Figure 3D and shows the piston sleeve bearing secured to the piston sleeve bearing retainer.

While the invention is susceptible to various modifications and alternative forms, specific embodiments thereof have been shown by way of example in the drawings and are herein described in detail. It should be understood, however, that it is not intended to limit the invention to the particular forms disclosed. On the contrary, the intention is to cover all modifications, equivalents, and alternatives falling within the spirit and scope of the invention as defined by the appended claims.

This detailed discussion of the apparatus of the invention is not intended to be exhaustive. It is readily envisioned that the apparatus may embody various types and styles of each element without departing from the spirit and scope of the invention.

Figures 1A-1F and Figures 3A-3D show an apparatus for sampling from the surface of land or a body of water a soil bed at the bottom of a bore hole in the presence of a drill string constructed according to a preferred

embodiment of the invention. The apparatus may be seen to comprise seven main subassemblies; namely a housing assembly 14 adapted to be dropped down a drill string or lowered by a wire line within the drill string and utilized for transporting the apparatus of the invention from the surface 31 of land or of a body of water 21 to a location adjacent the soil bed, a drill string latching sub assembly 17 positioned in the drill string adapted to receive the housing assembly, a sample tube assembly 23 extending below the bottom of the drill string 30 and beyond the drill bit 42 for penetrating and sampling the soil bed, selectively lockable means 20 to lock the housing into the drill string latching sub assembly 17 to enable the drill string 30 to apply an axial load to the housing assembly 14 through the load detector assembly 9 to the sample tube assembly 23, a load detector assembly 9 within the housing assembly 14 adapted to generate a first signal corresponding to loading as a function of time on the sample tube assembly 23, a movement detector assembly 16 within the housing assembly 14 adapted to generate a second signal corresponding to the upward displacement of a soil sample within the sample tube and a recorder assembly 18 within the housing assembly 14 adapted to record said first and second signals simultaneously.

THE HOUSING ASSEMBLY

The housing assembly 14 of the present invention is utilized to contain the load detector assembly 9, the movement detector assembly 16, the sample tube 23, the recorder assembly 18 and the selectively lockable means 20 down the well bore 13 and through the drill string 30 without removing the drill string 30 from the well bore 13. The operator drops the housing assembly 14 down the drill string 30 or lowers the housing assembly 14 down through the drill string 30 using a wire line 28 attached to an over shot assembly 29. The over shot assembly

attaches to overshot adaptor 22 at the top of the housing assembly 14. The operator lowers the apparatus of the invention through the drill string 30 to a location adjacent the bottom 12 of the well bore 13 drilled into a soil bed 35.

The drill string 30 may contain a latching sub assembly 17. The latch-in assembly 34 contains the selectively lockable means 20. The selectively lockable means locks into the drill string latching sub assembly 17 locking the housing assembly 14 into the drill string 30. The latch-in assembly 34 is secured to the adaptor for the latch-in assembly 62 by threads 60 formed on the latch-in assembly adaptor tapered member 26. The threads 60 are formed on tapered member 26 at the top of the latch-in assembly adaptor body 61.

The landing ring 24 attaches to the housing assembly 14. The drill string 30 contains drill string landing sub assembly 19 with an drill string landing ring 25 near the bottom of the drill string 30. The landing ring 24 engages the drill string landing ring 25 positioning the housing assembly 14 in the drill string 30 as the housing assembly 14 is lowered by a wire line 28 or dropped and allowed to free fall into place in the drill string 30. The selectively lockable means 20 engages the drill string latching sub assembly 17 when the landing ring 24 positionally engages the drill string landing ring 25. The landing ring 24 is fluted to allow fluid to pass through the flutes 45.

In land-based operations the operator may drill a well bore 13 using a drill bit 42 and then remove the drill string 30 from the well bore 13. The operator may remove the drill bit 42 and replace it with the housing 14. The housing 14 attaches to the bottom of the drill

string 30. The threads 60 on the tapered member 26 engage the threads at the bottom of the drill string 30. The operator may lower the drill string 30 with the attached housing 14 down into the well bore to a position adjacent the soil bed. The drill string then forces the sample tube 23 into the soil bed. The operator removes the drill string 30 to retrieve the housing 14 and the soil sample 50.

The housing assembly 14 includes a plurality of sleeves and annular transition members that form the exterior sheath of the housing assembly. The sleeves and transition members slide over the cylindrical members of the housing assembly. A plurality of cap screws secure the housing assembly sleeves and transition members to the cylindrical members.

The adaptor for the latch-in assembly 62 slides into housing exterior sleeve member 66. One or more cap screws 64 secure housing exterior sleeve member 66 to latch-in assembly adaptor body 61. The aperture 63 enables mechanical engagement and rotation clockwise and counterclockwise of cap screws 64. The cap screw threads 65 engage latch-in assembly adaptor body 61.

The instrument compartment plug 68 slides into the housing exterior sleeve member 66. One or more cap screws 70 secure housing exterior sleeve member 66 to instrument compartment plug 68. The aperture 72 enables mechanical engagement and rotation clockwise and counterclockwise of the cap screws 70. The cap screw threads 73 engage the instrument compartment plug 68.

An o-ring seal forms a water tight seal between the instrument compartment plug 68 and the exterior sleeve member. The o-ring seal includes an o-ring 74, an o-ring

groove 76 and an o-ring backing 75. The o-ring 74 fits within the o-ring backing 75. The o-ring backing 75 fits within the o-ring groove 76.

The housing exterior sleeve member 66 attaches to the housing member 106 by engaging threads 302. The aperture 118 enables mechanical engagement for rotation of the housing exterior sleeve member 66 clockwise and counterclockwise. The aperture 54 enables mechanical engagement for rotation of housing member 106 clockwise and counterclockwise.

An o-ring seal forms a water tight seal between the housing exterior sleeve member 66 and the housing member 106. The o-ring seal includes an o-ring 104, an o-ring groove 105 and an o-ring backing 103. The o-ring 104 fits within the o-ring backing 103. The o-ring backing 103 fits within the o-ring groove 105.

The upper housing member 106 slides into the lower housing member 126. The cap screws 124 secure the housing member 126 to the housing member 106. The apertures 130 enable mechanical engagement and rotation clockwise and counterclockwise of the cap screws 124. The cap screw threads 129 engage the housing member 106.

An o-ring seal forms a water tight seal between the housing member 106 and the housing member 126. The o-ring seal includes an o-ring 122, an o-ring groove 56 and an o-ring backing 123. The o-ring 122 fits within the o-ring backing 123. The o-ring backing 123 fits within the o-ring groove 56.

The housing member 126 attaches to the sleeve member 200 by engaging the threads 212. The aperture 109 enables mechanical engagement for rotation of the housing member

126 clockwise and counterclockwise. The landing ring 24 attaches to the sleeve member 200. The sleeve member 200 attaches to the upper portion of the load cell 208 by engaging the threads 125. The exterior load cell sleeve 222 slides over the load cell 208.

The sample head 202 attaches to the lower portion of the load cell 208 by the engaging threads 236. The aperture 203 enables mechanical engagement for clockwise and counterclockwise rotation of the sample head 202.

The sample head 202 slides into the sample tube 23. The cap screws 250 secure the sample tube 23 to the sample head 202. The aperture 251 enable mechanical engagement and rotation clockwise and counterclockwise of the cap screw 250. The cap screw threads 252 engage the sample head 202.

An o-ring seal forms a water tight seal between the sample head 202 and the sample tube 23. The o-ring seal includes an o-ring 242, an o-ring groove 244 and an o-ring backing 243. The o-ring 242 fits within the o-ring backing 243. The o-ring backing 243 fits within the o-ring groove 244.

The housing orifice 71 is used to facilitate machining of the latch-in assembly adaptor body 61.

THE DRILL STRING LANDING SUB ASSEMBLY

The drill string landing sub assembly 19 is configured to engage the landing ring 24 as the housing assembly 14 is dropped or lowered on a wire line 28 through the drill string 30. The drill string landing sub assembly 19 contains a drill string landing ring 25 to engage the landing ring 24 and halt the downward motion of

the housing assembly 14 with respect to the drill string 30.

THE SAMPLE TUBE ASSEMBLY

The sample tube 23 attaches to the sample head 202 as a member of the housing assembly 14. The housing assembly 14 latches into the drill string 30 by means of latch-in assembly 34. The sample tube 23 hangs down through the bottom of the drill bit 42. The sample head 202 attaches to the load cell 208. The axial load placed on the sample tube 23 is transmitted through the sample head 202 to the load cell 208.

There are numerous other means for taking a soil sample that may be used in the present invention and the apparatus or method of the invention is not limited to the use of a cylindrical sample tube. The invention contemplates the use of any shape sampler such as a square, rectangle, triangle or any other suitable shape. The invention also contemplates the use of any means or method of extracting the soil sample, such as coring, trepanning or any other suitable method or apparatus.

THE SELECTIVELY LOCKABLE MEANS ASSEMBLY

The selectively lockable means assembly is used to lock the housing assembly 14 into the drill string 30. In a preferred embodiment the selectively lockable means 20 is a set of latching dogs as shown in Figure 1B that disengage the recess 15 in the drill string latching sub assembly 17 when the overshot 29 and wire line 28 engage the overshot adaptor 22 and pull upwards on the apparatus housing assembly 14. The upward motion on overshot adaptor 22 moves sliding member 53 upward in groove 52 causing the latching dogs to pivot back into the latch-in assembly, disengaging the latching dogs. Upward tension on sliding member 53 causes the latching dogs to pivot into the

recesses of the latch-in assembly 34. The latching dogs are weighted so that they are normally pivoted outwardly to protrude from the exterior of the latch-in assembly 34. The selectively lockable means 20 automatically engages the drill string latching sub assembly 17 when the housing assembly 14 is lowered or dropped into place in the drill string.

THE LOAD DETECTOR ASSEMBLY

The load detector assembly is used to measure the force exerted on the sample tube 23. The load cell 208 attaches to the sample head 202 and the sample head attaches to the sample tube 23 as described in the description of the housing assembly. Retaining pin 234 passes though the exterior load cell sleeve 222, the load cell 208 and the interior load cell sleeve 228. The load exerted on the sample tube 23 is transmitted to the load cell 208. The strain gauges 210 are attached to the load cell web 206. The load cell web 206 is positioned in the load cell recess 214. The load cell wiring 92 runs from the strain gauges 210 through the load cell wiring connector 91, the feed through apertures 85, the feed through connector 84, the feed through apertures 246, the feed through apertures 87, the feed through connectors 81 and the load cell wiring passage 93 to connect the load cell to the instrument compartment interface connector 90. The protector sleeve 128 separates the load cell wiring from the piston sleeve 41.

The o-ring seals keep water out of the load detector assembly. The o-ring seals include an upper interior o-ring seal, an upper exterior o-ring seal, a lower interior o-ring seal and a lower exterior o-ring seal. The upper interior o-ring seal includes o-ring 220, an o-ring groove 221 and an o-ring backing 223. The lower interior o-ring seal includes an o-ring 218, an o-ring groove 217 and an

o-ring backing 215. The upper exterior o-ring seal includes an o-ring 204, an o-ring groove 205 and an o-ring backing 209 and o-ring 216. The lower exterior o-ring seal includes an o-ring 216, an o-ring groove 213 and an o-ring backing 219.

The upper and lower exterior o-ring seals fit between the load cell 208 and the exterior load cell sleeve 222. The upper and lower interior o-ring seals fit between the load cell 208 and the interior load cell sleeve 228. The exterior load cell sleeve 222 does not abut the sleeve member 200 leaving a space 224 between the exterior load cell sleeve 222 and the sleeve member 200. The exterior load cell sleeve 222 does not abut the sample head 202 leaving a space 226 between the sleeve 222 and the sample head 202. An annular space 108 exists between the piston sleeve 41 and the LVDT 101. An annular space 127 exists between the piston sleeve 41 and the protection sleeve 128.

There are numerous other means for measuring load that may be used in the invention and the apparatus of the invention is not limited to the use of a load cell. The apparatus of the invention contemplates the use of any suitable self-contained means for measuring load.

THE MOVEMENT DETECTOR ASSEMBLY

The movement detector assembly is utilized to measure the amount of soil sample 50 forced into the sample tube 23. The sample-follower piston 40 travels along the housing longitudinal axis and inside the sample tube 23. A piston sleeve 41 is attached to the sample-follower piston 40. The displacement of the piston head is measured by a means for measuring movement. In a preferred embodiment this means can be a linear displacement transformer LVDT 101 as shown in Figure 3D.

There are numerous other means for measuring displacement that could be used in a preferred embodiment and the apparatus of the invention is not limited to the use of a LVDT. The apparatus of the invention contemplates the use of any self contained means for measuring displacement.

The sample follower piston 40 includes a piston face 254 and a piston hub 256. The piston sleeve or hollow piston sleeve 41 slides into the piston hub. The cap screw 258 passes through the piston sleeve 41 and into the piston hub 256 and secures the piston sleeve 41 within the piston hub 256. The LVDT core rod 240 slides into the piston hub 256 and is secured into the piston hub by cap screw 258.

As shown in Figure 5, the LVDT 101 passes through the LVDT retaining bracket orifice 230 into the LVDT retaining bracket 112. The LVDT retaining bracket 112 engages the top portion 96 of the LVDT and clamps the LVDT 101 in place. The LVDT retaining bracket 112 slides over the LVDT 101 and abuts the top portion 96 of the LVDT. The cap screw 116 passes through the aperture 120 and engages the LVDT retaining bracket 112 to close the gap 55 and reduce the diameter of the orifice 230 and tighten the LVDT retaining bracket 112 around LVDT 101. LVDT retaining bracket 112 fits into the LVDT retaining groove 97 at the top portion 96 of the LVDT. The threads 117 engage the LVDT retaining bracket 112. The orifice 119 in the cap screw head 118 enables mechanical engagement and rotation clockwise and counterclockwise of cap screw 116.

The cap screw 114 passes through the aperture 121 in the LVDT retaining bracket 112 and secures the retaining bracket to housing member 106. The cap screw threads 107 engage the housing member 106. The aperture 113 enables

mechanical engagement and rotation clockwise and counterclockwise of the cap screw 77. The LVDT wiring 92 passes through the wiring passage 110 and connects the LVDT to the instrument compartment interface connector 90.

The piston sleeve 41 slides along the longitudinal axis of the housing on piston bushings 262 and 264. The upper piston bushing 262 also serves as stop for engaging the piston stop 43. The piston stop 43 keeps the piston from falling out of the end of the housing assembly 14. The piston bushing 262 is held in place by the bushing retainer 266. The bushing retainer 266 is secured to the sample head 202 by the cap screw 268. The cap screw threads 269 engage the sample head 202 to secure the bushing retainer 266. The piston bushing 264 is held in place by the bushing retainer 270. The bushing retainer 270 is secured to the sample head 202 by cap screw 272. The cap screw threads 271 engage the sample head 202 to secure the bushing retainer 270. The piston stop 43 engages the bushing 262.

The check valve 278 allows fluid or other matter in sample tube 23 to escape through the escape valve orifice 277 as the soil sample fills the sample tube 23 and displaces any water or other matter within the sample tube 23. The reduced diameter portion of the check valve 278 forms a seat 275 for the ball 274. The check valve ball 274 moves up and away from the valve seat 275 while fluid escapes during soil capture. The retaining pin 276 prevents the ball 274 from falling out of the valve. When the housing withdraws from the soil, the ball 274 returns to a resting position and rests on the valve seat 275 and seals the escape valve orifice 277 to form a suction on and retain the soil sample 50 in the sample tube 23.

THE RECORDER ASSEMBLY

The recorder assembly is utilized to record the data measured from the load detector and movement detector and any other detector simultaneously. The data recorder assembly includes the battery pack 38, the data acquisition system 39 and the electronics package 37. The wiring 300 connects the battery pack 38 to the data acquisition system 39 and the wiring 301 connects the battery pack to the electronic package. The wiring 301 connects the electronics package 37 to the data acquisition system 39. The wiring 303 connects the instrument compartment interface connector 90 to the data acquisition system 39 and the electronics package 39.

The LVDT wiring 99 connects the LVDT to the instrument compartment interface connector 90 and thus to the recording assembly. The load cell wiring 92 connects the load cell to the instrument compartment interface connector 90 and thus to the recording assembly. The battery pack 38, the data acquisition system 39 and the electronics package are contained in the instrument compartment 36.

The external data ports 94 are mounted on the housing recess 102 to provide a means for retrieving data from the data recorder assembly. The housing recess 102 keeps the external data ports 94 recessed and protected during operations. The rubber nipple 95 slides over and protects the external data ports 94. The external data port wiring 100 connects the external data ports 94 to the data acquisition system 39 for retrieval of data.

The apparatus of the invention is not limited to the use of the specific data acquisition system described here. The apparatus of the invention contemplates the use of any self-contained means for recording data. Thus, the

invention contemplates the use of optical disk storage, magnetic disk storage, and the like. The invention also contemplates the use of self-contained data acquisition systems that do not store data but transmit data to the surface without the use of a physical data cable umbilical from the surface to the apparatus of the invention.

OPERATION OF THE INVENTION

A. APPARATUS DEPLOYMENT AND RETRIEVAL OPERATIONS

In operation, the operator drills an well bore 13 into a soil bed 35 and raises the drill bit 42 approximately 2-5 feet off the soil bed 12 at the bottom of the well bore 13. The operator either drops the housing assembly 14 down through the well bore 13 or he may lower the housing assembly 14 on a wire line 28 through the well bore without removing the drilling apparatus 30 from the well bore 13. To lower the housing assembly 14 on a wire line 28, the operator attaches a wire line 28 and overshot 29 to the overshot adaptor located on the top of the housing assembly 14 or tool.

The selectively lockable means 20, located in the latch-in assembly 34, engages the latch recess 15 in the drill string sub assembly 17 located above the drill bit 42 at the bottom of the drill pipe.

The landing ring 24 formed on the apparatus housing assembly 14 abuts the drill string landing ring 25 at the bottom of the drill string 30 during deployment to limit the downward progress of the housing assembly 14. The fluted exterior of the landing ring 24 allows fluid to pass through the flutes 45 as the housing assembly 14 moves through the drill string 30.

The operator may retrieve the housing assembly 14 by lowering an overshot 29 on the end of a wire line 28 which

engages the top of the housing assembly 14. As the wire line 28 pulls up on the latch-in assembly 34, the latching dogs rotate back into the latch-in assembly 34 and disengage the recess 15 in drill string latching sub assembly 17. The wire line 28 pulls the housing assembly 14 to the surface where the user recovers the data stored by the data acquisition system 39.

In land-based operations the operator may drill a well bore 13 using a drill bit 42 and then remove the drill string 30 from the well bore 13. The operator may remove the drill bit 42 and replace it with the housing 14. The housing 14 attaches to the bottom of the drill string 30. The threads 60 on the tapered member 26 engage the bottom of the drill string 30. The operator lowers the drill string 30 with the attached housing 14 down into the well bore to a position adjacent the soil bed. The drill string 30 then forces the sample tube 23 into the soil bed. The operator removes the drill string 30 to retrieve the housing 14 and the soil sample 50.

B. LOAD AND DISPLACEMENT MEASUREMENT OPERATIONS

As the drill string is lowered in the well bore, the LVDT 101 measures the displacement of the sample-follower piston 40 within the sample tube 23. The sample-follower piston 40 follows the progress of the soil sample 50 within the sample tube 23, as the drill string forces the sample tube into the soil bed. The load cell 208 measures the force exerted on the sample tube 23. The data acquisition system 39 concurrently reads and stores the force and displacement measurements as a function of time.

C. DATA CAPTURE OPERATIONS

The sample tube 23 normally penetrates the soil bed 12 at the bottom of the well bore 13 at a variable rate, enabling the determination of dynamic loading

characteristics. The rate is uncontrolled in the sense that it is subject to such factors as inconsistencies in the soil bed and load fluctuations in the drill string. The tool can operate in a hostile sea state without data degradation because the data measurements are taken as a function of time. The operator retrieves the data stored by the data acquisition system 39 through the external data ports 94 after the tools returns to the surface.

The instrument compartment 36 contains the data acquisition system 39, the battery pack 38 and the electronics package 37. The instrument compartment interface connector connects the data acquisition system 39, the battery pack 38 and the electronics package 37 to the load cell 208, and LVDT 101 and external data ports 94. The instrument compartment interface connector 90 accommodates wire connections from the exterior data ports 94, the load cell 208 and from the LVDT 101.

The soil sampling and data gathering apparatus tool is totally self-contained. The tool provides its own power supply, measuring instruments and data acquisition system. A battery pack 38 provides electric power to the load cell, the LVDT, the data acquisition system and the electronics package. A plurality of o-ring seals isolate the apparatus so that it is not contaminated by the exterior environment nor does it contaminate the exterior environment.

The electronics package 37 provides an electronic interface between the data acquisition system 39 and the load cell 208, LVDT 101 and external data ports 94. The data acquisition system 39 may be comprised of an industry standard module such as the *Tattletale* Model V, available from ONSET Computer Corp., P.O Box 1030, 199 Main Street, N. Falmouth, MA 02556.

The data acquisition system typically includes a central processing unit, a universal asynchronous receiver/transmitter, an analog to digital converter, static RAM and EPROM. The data acquisition system takes analog signals from the load cell and LVDT and converts them to digital signals. The data acquisition system samples the analog signals from the load cell and LVDT at regular intervals, as for example every 10 milliseconds, converts these analog measurements into digital signals and stores the digital signals. The resulting data measurements represent a force curve 32 and displacement curve 33 as a function of time during the sampling session.

The invention is not limited to any particular conventional data acquisition system. The invention contemplates any suitable data sampling and storage device, such as optical disc or any other means of data storage. There are numerous uses for the recovered measurement data. It is contemplated that additional uses and interpretations will develop as the users of the invention gain experience with the apparatus and method and the data derived from its use.

D. SOIL CAPTURE OPERATION

The sampling tube 23 typically hangs down about 2 feet beyond the bottom of the drill bit 42. The operator allows the drill string 30 to descend at an uncontrolled rate which presses the sample tube 23 into the soil bed at a variable rate. The pressure from the drill string forces a soil sample 50 into the sample tube 23 as the sample tube 23 penetrates the soil bed 12 at the bottom of the well bore 13. The sample-follower piston 40 tracks the progress of the soil sample 50 as it enters the sampling tube 23. The check valve 278 allows fluid to escape from the sampling tube 23 as the soil sample 50 displace fluid

in the sample tube 23. When the sample tube 23 withdraws from the soil bed 12, the check valve ball 274 seats and seals to provide suction that holds the soil sample 50 in the sample tube 23.

The apparatus captures a soil sample 50 in the sampling tube 23, and gathers data on the soil bed 12, in situ, concurrently. The uncontrolled descent of the drill string 30 forces the sampling tube 23 into the soil at a variable penetration rate, enabling the user to determine the dynamic and static loading characteristics of the soil bed. The time measurements also facilitate data corrections for variable loading.

E. LOAD MEASUREMENT OPERATIONS

The load cell 208 measures the force exerted on the sample tube 23. The force on the sample tube 23 is transmitted from the sample tube 23 through the sample head 202 to the load cell 208. The top of the load cell 208 screws into the sleeve member 200 and the bottom of the load cell 208 screws into sample head 202.

The load cell wiring 92 from the load cell 208 connects to the load cell wiring connector 91 and passes upwardly through the load cell wiring passage 93 and connects to the instrument compartment interface connector 90. The data acquisition system 39 records the load measured by the load cell as a function of time.

A plurality of strain gauges 210 attach to the load cell web 206 to determine the load as a average of the measurements taken at the strain gauges. The load cell wiring 92 runs from the strain gauges 210 up through the load cell wiring passage 93. The load cell wiring passage 93 is sealed to keep water and other contaminants. The load cell web 206 is positioned between the interior load

cell sleeve 228 and the exterior load cell sleeve 222. The load cell is sealed by a series of upper and lower load cell o-rings 204, 220, 216 and 218 placed between the load cell and the interior and exterior load cell sleeves. The exterior load cell sleeve 222 protects the load cell from the environment. The outer load cell sleeve is separated from the sleeve member 200 by a space 224 and a space 226 so that the axial load passes through the load cell instead of sleeve member 200.

F. DISPLACEMENT MEASUREMENT OPERATIONS

The sample-follower piston 40 hangs down inside the sample tube 23. The sample-follower piston 40 follows the soil sample 50 into the sampling tube 23 as the drill string 30 pushes the sampling tube 23 into the soil bed 12. The LVDT core rod 240 attaches to the soil follower piston hub 256 by means of cap screw 259. The LVDT 101 measures the progress of the soil sample 50, as it moves into the sample tube 23 displacing the sample-follower piston 40 and attached LVDT core rod 240. The LVDT core rod 240 moves within the LVDT 101 and generates an electrical signal proportional to the displacement of the LVDT core rod 240 and sample-follower piston 40. The cap screw 258 allows for adjustment of the sample-follower piston 40 position relative to the LVDT core rod 240 to fix the piston face 254 on the LVDT core rod 240 at the calibrated null position of the LVDT 101.

The LVDT 101 remains environmentally isolated and water tight even at extreme water pressure through the use of the LVDT o-ring. LVDT retaining screw 114 secures the LVDT retaining bracket 112 to housing member 106.

The piston sleeve 41 slides on replaceable bushings 262 and 264. The bushings keep the piston sleeve aligned along the longitudinal axis of the apparatus without

rubbing against the LVDT. The piston sleeve annular stop 43 abuts the upper piston sleeve bushing 262 and halts the downward motion of the sample follower piston 40.

SUMMARY OF ADVANTAGES

It will be appreciated that the method and apparatus for determining the dynamic characteristics of a soil bed by penetrating a soil bed at a variable penetration rate and measuring the force and displacement of the sampling device as a function of time of the present invention, provide certain significant advantages.

The present invention is self-contained and environmentally sealed. The apparatus is capable of operating on land or at great depths under the sea. The apparatus is simple and easy to build, with fewer parts than known systems. The apparatus reduces or eliminates the need for a physical data and control umbilical to the surface. The method can be performed on land or in a benign or hostile sea state without the need for motion compensation. The method may also be performed more quickly than known methods. The concurrent acquisition of a core or soil sample as well as load data and penetration data provides a valuable insight into the characteristics of a soil bed and its pile carrying capacity.

CLAIMS:

1. Apparatus for sampling a soil bed at the bottom of a bore hole in the presence of drill string which comprises:

a housing adapted to be positioned in a drill string for transporting said sampling apparatus from the surface to a location adjacent the soil bed;

a receiving assembly positioned in the drill string adapted to receive the housing;

a sample tube extending below the housing for penetrating the soil bed;

selectively lockable means to selectively lock the housing into the receiving assembly and mechanically transmit compression and tension forces between the drill string and the sample tube sufficient to enable the sample tube to penetrate the soil bed and displace a soil sample upwardly into the sample tube;

a load detector within the housing adapted to generate a first signal corresponding to compression and tension forces as a function of time on the sample tube;

a movement detector within the housing adapted to generate a second signal corresponding to the upward

displacement as a function of time of a soil sample within the sample tube; and

a recorder within the housing adapted to record the first and second signals concurrently.

2. The apparatus of claim 1 in which the sampler is a right circular cylinder capable of retaining a sample of the soil bed which enters the sampler during such penetration.

3. The apparatus of claim 1 or 2 in which the load detector comprises a load cell.

4. The apparatus of claim 3 in which the load detector is located between the sample tube and the drill string.

5. The apparatus of any of claims 1 to 4, in which said movement detector is a linear displacement transducer.

6. The apparatus of claim 5 in which said linear displacement transducer comprises a piston within a right

circular cylinder that follows the soil sample up into the cylinder during penetration.

7. The apparatus of any of claims 1 to 6, which is sealed so that the force and movement signals can be taken at depth without environmental contamination of said housing.

8. A method of sampling a soil bed using a drill string, which comprises the steps of:

releasably engaging a sample tube within the drill string such that a length of the tube extends through and below the bottom of the drill string;

lowering the drill string to impose a compression force on the tube sufficient to thereby penetrate the soil bed and displace a soil sample into the tube;

detecting the compression forces imposed on the tube as a function of time during such penetration;

detecting the displacement of the soil sample into the tube with time during such penetration;

recording down the well during such penetration the compression forces and displacement so detected; and

retrieving through the drill string the sample tube together with the records recorded down the well.

9. The method of claim 8 which further comprises the steps of:

raising the drill string to withdraw the tube from the soil bed;

detecting the tension forces on the tube as a function of time during such withdrawal;

detecting the displacement, if any, of the soil sample within the tube with time during such withdrawal; and

recording down the well during such withdrawal the tension forces and displacement so detected.

10. The method of claim 9 wherein the compression and tension forces are detected using strain gauges.

11. The method of claim 9 or 10 wherein the displacement is measured using an LVDT.

12. The method of claim 9, 10 or 11 wherein the displacement and compression and tension forces are detected concurrently.

13. The method of any of claims 9 to 12 which further comprises displaying the displacement and compression and tension force measurements.

14. Apparatus for sampling a soil bed at the bottom of a bore hole in the presence of a drill string having a central passageway which comprises:

a housing adapted to be attached to the bottom of the drill string and lowered to a location adjacent the soil bed;

a sample tube extending below the housing capable of penetrating the soil bed;

an attachment means to connect said housing to the bottom of the drill string to enable compression and tension forces to be transmitted between the drill string

and said sample tube sufficient to force said sample tube to penetrate the soil bed and displace a soil sample upwardly into the sample tube;

a load detector within the housing adapted to generate a first signal corresponding to the compression and tension forces on the sample tube as a function of time;

a movement detector within the housing adapted to generate a second signal corresponding to the upward displacement of a soil sample within the sample tube as a function of time; and

a recorder within the housing adapted to record the first and second signals concurrently.

15. The apparatus of claim 14 in which the sampler is a right circular cylinder capable of retaining a sample of the soil bed which enters the sampler during such penetration.

16. The apparatus of claim 14 in which the load detector comprises a load cell.

17. The apparatus of any of claims 14 to 16 in which the load detector is capable of measuring both compression and tension forces.

18. The apparatus of any of claims 14 to 17 in which said movement detector is a linear displacement transducer.

19. The apparatus of claim 18 in which said linear displacement transducer comprises a piston within a right circular cylinder that follows the soil sample up into the cylinder during penetration.

20. Apparatus for sampling a soil bed at the bottom of a bore hole which comprises:

a housing adapted to be dropped down a drill string or lowered from a wire line within the drill string, said housing configured to be landed within the drill string;

a sample tube extending below the housing capable of passing through the central passageway of a coring bit or a drag bit and penetrating into a soil bed;

a reversible locking member carried by the housing operable to lock the housing within the drill string in a manner to enable the axial load on the drill string to be transmitted through the housing to the sample tube;

a load detector within the housing adapted to generate a first signal corresponding to such axial load as a function of time;

a movement detector within the housing adapted to generate a second signal corresponding to the upward displacement as a function of time of a soil sample within the sample tube; and

a recorder within the housing adapted to record said first and second signals concurrently.

21. The apparatus of claim 20 in which said sample tube is a right circular cylinder capable of retaining a sample of the soil bed which enters the sampler during such penetration.

22. The apparatus of claim 20 or 21 in which the load detector comprises a load cell.

23. The apparatus of any of claims 20 to 22 in which said movement detector is a linear displacement transducer.

24. The apparatus of any of claims 20 to 23 which further comprises a battery pack within the housing capable of powering the detectors and the recorders.

25. The apparatus of claim 21 wherein the movement detector includes a piston within the sample tube which is positionally responsive to a sample within the sample tube.

26. Apparatus for sampling a soil bed substantially as specifically described herein with reference to the accompanying drawings.

27. A method of sampling a soil bed substantially as specifically described herein with reference to the accompanying drawings.

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Dated: January 24, 2018
Electronic Signature for Joseph P. Anderson, III: /Joseph P. Anderson, III/

ATTORNEY DOCKET NO. 36362.0150U2-
VIA EFS-WEB
PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of	)	
	)	
CHRISTOPHER L. DRENTH, ET AL.	)	Art Unit: 3676
	)	
Application No.: 14/692,484	)	Examiner: Michael R. Wills III
	)	
Filing Date: April 21, 2015	)	Confirmation No.: 3851
	)	
For: **CORE BARREL HEAD ASSEMBLY WITH AN INTEGRATED SAMPLE ORIENTATION TOOL AND SYSTEM FOR USING SAME**	)	

SUPPLEMENTAL INFORMATION DISCLOSURE STATEMENT

MAIL STOP AMENDMENT
Commissioner for Patents
P. O. Box 1450
Alexandria, VA 22313-1450

BALLARD SPAHR LLP
Customer No. 23859

January 24, 2018

Commissioner:

Pursuant to the requirements set forth in 37 C.F.R. § 1.56, Applicants now submits a list of documents known to Applicants or Applicants' attorneys. Pursuant to 37 C.F.R. § 1.98(a)(2)(iv), and for the Examiner's review, Applicants have enclosed (1) copies of documents from the prosecution of related non-U.S. patent applications and (2) copies of non-U.S. patents or non-U.S. patent application publications. In accordance with 37 C.F.R. § 1.98(a)(2), copies of any cited U.S. patent or U.S. patent application publication documents are not enclosed.

Regarding the documents from the prosecution of related non-U.S. patent applications, Applicants have identified the prosecution record of non-U.S. patent applications as the source for each document. The information provided mirrors the requirements for cited non-U.S. patent applications as set forth by 37 C.F.R. § 1.98(b).

Applicants respectfully request consideration of all documents submitted in the present Supplemental Information Disclosure Statement and List and entry into the record for the present application (Application No. 14/692,484).

Pursuant to 37 C.F.R. § 1.97(b)(4), Applicants submit that this document is timely filed in that the Patent and Trademark Office has not yet mailed to Applicants a first Office Action on the merits after the filing of a Request for Continued Examination. Applicants submit that no fee is due; however,

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Reflex USA LLC v. Longyear TM, Inc. and Globaltech Corporation Pty Ltd.

Applicants hereby authorize the Commissioner to charge to Deposit Account No. 14-0629 any fee that may be required to effect the consideration and entry of this Supplemental Information Disclosure Statement and List and the references contained therein.

Respectfully submitted,

Electronic Signature: /Joseph P. Anderson, III/
Joseph P. Anderson, III
Registration No.: 59,245
BALLARD SPAHR LLP
Correspondence Customer Number: 23859

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Reflex USA LLC v. Longyear TM, Inc. and Globaltech Corporation Pty Ltd.

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INFORMATION DISCLOSURE STATEMENT BY APPLICANT

(Use as many sheets as necessary)

Sheet 1 of 2

Complete if Known	
Application Number	14/692,484
Filing Date	April 21, 2015
First Named Inventor	Christopher L. Drenth
Art Unit	3676
Examiner Name	M. R. Wills, III
Attorney Docket Number	36362.0150U2-

U. S. PATENT DOCUMENTS

Examiner Initials*	Cite No.[1]	Document Number Number-Kind Code[2] *(if known)*	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear
	A	US-2,944,792-A	07-12-1960	Gros	

FOREIGN PATENT DOCUMENTS

Examiner Initials*	Cite No.[1]	Foreign Patent Document Country Code[3] Number[4] Kind Code[5] *(if known)*	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages Or Relevant Figures Appear	T[6]
	B	GB-2243173-A	10-23-1991	Seafloors Eng Inc.		
	C	WO 2008/113127 A	09-25-2008	2iC Australia Pty Ltd.	Corresponds to EP 2134921-A1	

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NON PATENT LITERATURE DOCUMENTS

Examiner Initials*	Cite No.[1]	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc.), date, page(s), volume-issue number(s), publisher, city and/or country where published.	T[2]
	D	Extended European Search Report issued on October 17, 2017 by the European Patent Office for Application No. 15782230.5, which was filed on April 21, 2015 and published as EP 3134600 on March 1, 2017 (Inventor- Drenth et al.; Applicant- Longyear TM, Inc. et al.; Attorney Docket No.- 36362.0150EP1) (9 pages).	

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U. S. PATENT DOCUMENTS

Examiner Initials*	Cite No.[1]	Document Number Number-Kind Code[2] *(if known)*	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear
	A	US-2,944,792-A	07-12-1960	Gros	

FOREIGN PATENT DOCUMENTS

Examiner Initials*	Cite No.[1]	Foreign Patent Document Country Code[3]-Number[4]-Kind Code[5] *(if known)*	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages Or Relevant Figures Appear	T[6]
	B	EP-2134921-A1	12-23-2009	2iC Australia Pty Ltd.	Corresponds to WO 2008/113127 A	
	C	GB-2243173-A	10-23-1991	Seafloors Eng Inc		

Examiner Signature		Date Considered	

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Dated: January 17, 2018 Signature: /Joseph P. Anderson, III/ (Joseph P. Anderson, III)

PTO/SB/08b (07-09)
Approved for use through 07/31/2016. OMB 0651-0031
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
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Substitute for form 1449/PTO

INFORMATION DISCLOSURE STATEMENT BY APPLICANT

(Use as many sheets as necessary)

Sheet	2	of	2

Complete if Known	
Application Number	14/692,484
Filing Date	April 21, 2015
First Named Inventor	Christopher L. Drenth
Art Unit	3676
Examiner Name	M. R. Wills, III
Attorney Docket Number	36362.0150U2-

NON PATENT LITERATURE DOCUMENTS

Examiner Initials*	Cite No.[1]	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc.), date, page(s), volume-issue number(s), publisher, city and/or country where published.	T[2]
	D	Extended European Search Report issued on October 17, 2017 by the European Patent Office for Application No. 15782230.5, which was filed on April 21, 2015 and published as EP 3134600 on March 1, 2017 (Inventor- Drenth et al.; Applicant- Longyear TM, Inc. et al.; Attorney Docket No.- 36362.0150EP1) (9 pages).	

Examiner Signature		Date Considered	

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

[1] Applicant's unique citation designation number (optional). [2] Applicant is to place a check mark here if English language Translation is attached.

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
25 September 2008 (25.09.2008)

PCT

(10) International Publication Number
WO 2008/113127 A1

(51) International Patent Classification:
E21B 25/16 (2006.01) *E21B 49/02* (2006.01)

(21) International Application Number:
PCT/AU2008/000395

(22) International Filing Date: 19 March 2008 (19.03.2008)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
2007901412 19 March 2007 (19.03.2007) AU

(71) Applicant *(for all designated States except US)*: **2iC AUSTRALIA PTY LTD** [AU/AU]; Unit 2/10 McElligott Court, Canning Vale, Western Australia 6155 (AU).

(72) Inventors; and
(75) Inventors/Applicants *(for US only)*: **BEACH, Andrew** [AU/AU]; Level 2/10 McElligott Court, Canning Vale, Western Australia 6155 (AU). **BEACH, Shayne** [AU/AU]; Unit 2/10 McElligott Court, Canning Vale, Western Australia 6155 (AU). **MCLEOD, Gavin** [AU/AU]; Unit 2/10 McElligott Court, Canning Vale, Western Australia 6155 (AU).

(74) Agent: **GRIFFITH HACK**; Level 19, 109 St George's Terrace, Perth, WA 6000 (AU).

(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, 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, HR, HU, IE, IS, IT, LT, LU, LV, MC, MT, NL, NO, 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*

(54) Title: A CORE ORIENTATION TOOL

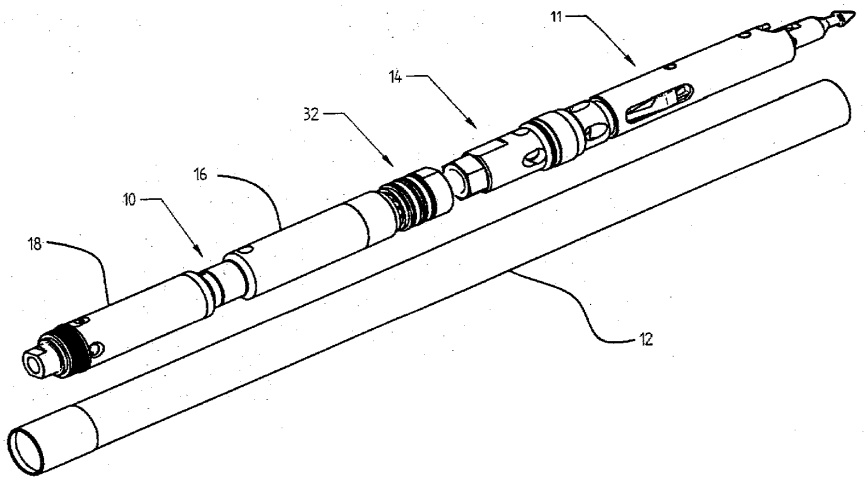


Figure 1

(57) Abstract: A core orientation tool (10) for providing an indication of orientation of a core sample (112) comprises an electronic orientation device (20), which upon receipt of a trigger signal, logs one or more indications of orientation of the tool (10). A trigger system (24) provides trigger signals to the electronic device (20) based one or both of (a) detecting one or more downhole events and (b) the effluxion of time. The downhole events relate to the action of core breaking and may include detecting: uphole motion of the tool; and, cessation of drilling and commencement of drilling.

WO 2008/113127 A1

A CORE ORIENTATION TOOL

Field of the Invention

The present invention relates to a core orientation tool that can provide directional characteristics of a geological core sample extracted from the subsurface.

Background of the Invention

Core sampling is used to allow geological surveying of the subsurface for various purposes including exploration and/or mine development. An analysis of the material within the core sample provides information of the composition of the subsurface. However in order to accurately interpret the information obtained from the core sample, it is necessary to have knowledge of the orientation of the core sample relative to the subsurface from which it was extracted.

Applicant has developed numerous devices, systems and methods for orientating a core sample including a method of orientating a core sample described in co-pending Australian patent application no. 2006901298; an orientation head described in International publication No. WO 07/109848; a core orientation system described in International publication No. WO 07/1137356; and an orientation device for a core sample described in International publication No. WO 03/038232; the contents of each of which is incorporated herein by way of reference.

The present invention is the result of Applicant's further research and development in the field of core orientation.

It is to be understood that, if any prior art publication is referred to herein, such reference does not constitute

an admission that the publication forms a part of the common general knowledge in the art, in Australia or any other country.

In the claims of this application and in the description of the invention, except where the context requires otherwise due to express language or necessary implication, the words "comprise" or variations such as "comprises" or "comprising" are used in an inclusive sense, i.e. to specify the presence of the stated features but not to preclude the presence or addition of further features in various embodiments of the invention.

Summary of the Invention

According to a first aspect of the present invention there is provided a core orientation tool for providing an indication of *in situ* orientation of a core sample extracted from a borehole by a core drill the tool comprising:

an electronic orientation system coupled with the core drill, the electronic orientation system configured, upon receiving a trigger signal, to log one or more first indications of orientation of the tool; and,
a trigger system that provides the trigger signal upon detecting one or more downhole events associated with operation of the core drill.

According to a second aspect of the present invention there is provided a core orientation tool for providing an indication of *in situ* orientation of a core sample extracted from a borehole by a core drill the tool comprising:

an electronic orientation system coupled with the core drill, the electronic orientation system configured, upon

receiving a trigger signal, to log one or more first indications of orientation of the tool; and,
a trigger system that provides the trigger signal upon one or both of (a) detecting one or more downhole events associated with operation of the core drill, and (b) effluxion of time.

According to a third aspect of the present invention there is provided a core orientation tool for providing an indication of *in situ* orientation of a core sample extracted from a borehole by a core drill the tool comprising:

an electronic orientation system coupled with the core drill, the electronic orientation system configured to log one or more first indications of orientation of the tool; and,
a trigger system that provides a trigger signal upon detecting one or more downhole events associated with operation of the core drill; and,
wherein tool is configured to associate the one or more first indications of orientation with the trigger signal.

The trigger signal may be one of a plurality of trigger signals. Moreover, the tool may be further configured to log different first indications of orientation, for example dip, roll and azimuth upon receipt of different trigger signals.

The one or more downhole events may comprise respective physical events arising from motion of the tool or the drill in the borehole.

For example, the motion may comprise one or a combination of:
(a) motion in an uphole direction;

(b) a change in motion from motion having a linear component in a downhole direction to motion having no linear component;

(c) a change in motion from motion in a downhole direction to motion in an uphole direction;

(d) a change in motion from no linear motion to motion in an uphole direction;

(e) a change in characteristics of vibration motion on the tool or drill arising from the cessation or commencement of drilling;

(f) a change in speed of linear motion of the tool; and,

(g) a change in the rate or direction of rotation around the tool's longitudinal, lateral or normal axis.

(h) any change in velocity (speed and/or direction of movement).

The trigger signal may be provided upon detecting a predetermined sequence of downhole events such as a cessation of drilling followed by motion of the tool in an uphole direction.

The sequence of events may further comprise commencement of drilling prior to the cessation of drilling.

Other downhole events that may be detected by the electronic orientation device and used in producing the trigger signal comprise:
(a) detecting contact of a backend assembly to which the tool is coupled hitting a landing ring in the core drill;

(b) the backend assembly hitting a water table in the event that the drill is operated in the borehole below the water table;

(c) detecting release of the backend assembly from a wire line when initially inserting a core tube into the core drill;

(d) the core drill tagging a toe of the hole;

(e) an overshot hitting and latching onto the backend assembly;

(f) retrieval of the backend assembly from the drill hole; and,

(g) a change in the flow of fluid through or around the backend assembly.

Instead of utilising detected changes in vibration characteristics of the tool which are caused when the drill is cutting a core, the stopping and starting of drilling may be detected by sensing actual rotation of the core drill by using sensors or devices mounted on or adjacent to a rotating side of the backend assembly. Such devices may comprise an inductive RPM sensor, accelerometer or a gyroscope.

The tool 10 may be further configured to log or record time between one or more of the downhole events, for example the time between cessation of drill and motion in an uphole direction; and/or time between cessation of drilling and the provision of the trigger signal. Such information may be beneficial in accessing the accuracy or degree of confidence in the orientation readings.

According to a further aspect of the present invention there is provided a core retrieval system for a core drill comprising:

a core tube having an uphole end and a downhole end, the downhole end provided with an opening for receiving a core sample cut by the core drill; and,

a core orientation tool in accordance with the first aspect of the present invention wherein the core orientation tool is coupled to the core tube at a location uphole of the downhole end of the core tube.

The core retrieval system may further comprise a backend assembly coupled to the uphole end of the core tube and wherein the core orientation tool is attached to the backend assembly uphole of the uphole end of the core tube.

A further aspect of the present invention provides a method of logging *in situ* orientation of a core sample extracted from the ground by a core drill comprising:

coupling an electronic core orientation device in a known spatial relationship to a core sample cut by the core drill;

configuring the electronic core orientation device to log one or more indications of orientation of the device upon receipt of a trigger signal; and,

providing the trigger signal upon detecting one or more downhole events associated with the operation of the core drill.

The downhole events may be indicative of a, or an imminent, core break.

Detecting of the one or more downhole events may comprise detecting an uphole motion of the device.

The detecting of the downhole event may comprise detecting a cessation of drilling prior to detecting the uphole motion of the device. The detecting may further comprise detecting commencement of drilling prior to detecting cessation of drilling. Further, the detecting may comprise detecting a cessation of downhole movement of the device prior to detecting the commencement of drilling.

In one embodiment the tool comprises a switch that is activated by the tool, a downhole device such as an inner barrel assembly to which the tool is attached, or the drill, tagging the toe of the borehole. The switch may comprise a Hall effect switch, an optical switch, a pressure switch, and a mechanically operated electrical switch.

The first indications of orientation may comprise one or a combination of borehole dip, borehole azimuth, core orientation, core dip and core azimuth.

According to a further aspect of the present invention there is provided a core retrieval system for a core drill comprising:

an inner core tube having an uphole end and an opposite downhole end provided with an opening for receiving a core cut by the core drill; and,

a core orientation tool coupled to the inner core barrel and movable inside the inner core tube in an uphole direction by abutment with the core, the core orientation tool comprising an electronic orientation device which upon receiving a trigger signal logs one or more first indications of orientation of the tool;

a trigger system that provides the trigger signal to the electronic orientation device; and

a core face orientation device which records rotational orientation of a core sample, wherein the electronic orientation device is in a known rotational position relative to the core face orientation device.

According to another aspect of the present invention there is provided a core retrieval system for a core drill comprising:

a core tube having an uphole end and an opposite downhole end provided with an opening for receiving a core sample cut by the core drill;

a core orientation tool coupled to the inner core tube and movable inside the inner core barrel in an uphole direction by abutment with the core sample, the core orientation tool comprising: an electronic orientation device which, upon receiving a trigger signal logs one or more first indications of orientation of the tool; and a trigger system that provides the trigger signal to the electronic orientation device.

A further aspect of the present invention provides a core orientation apparatus for providing an indication of orientation of a core sample extracted from a borehole by a core drill the apparatus comprising:

an electronic orientation device which upon receiving a trigger signal logs one or more first indications of orientation of the tool;

a trigger system that provides the trigger signal to the electronic orientation device; and

one or more secondary orientation devices which provide one or more second indications of orientation of the core or borehole, wherein the electronic orientation device is in a known rotational position relative to the one or more secondary orientation devices.

The trigger system may provide the trigger signal on the basis of effluxion of time from a reference time. For example the reference time could be the time the tool is inserted into a core drill, or at a time when or after the core face orientation device records the orientation of the core face.

In an alternate embodiment, the trigger signal is delivered on multiple occasions during a period between the core orientation tool being inserted into the core drill and a time after the core face orientation device records the orientation of the core face.

In one embodiment, the trigger system provides the trigger signal to the electronic orientation device upon detecting one or more downhole events associated with the operation of the drill. The one or more downhole events may comprise one or more physical events arising from the motion of the tool in the borehole.

Brief Description of the Drawings

Embodiments of the present invention will now be described by way of example only with reference to the accompanying drawings in which:

Figure 1 is a schematic representation of an inner barrel assembly and core tube to which an embodiment of a core orientation tool is coupled;

Figure 2 is a cutaway view of the core orientation tool and adjacent parts of the inner barrel assembly to which it is coupled.

Figure 3 is a partially exploded schematic representation of a further embodiment of a core orientation tool in accordance with the present invention;

Figure 4 is a partially exploded representation of a third embodiment of the core orientation tool;

Figure 5 is a section view of the core orientation tool shown in Figure 4; and

Figure 6 depicts the use of a template for transferring indications of core orientation captured by the tool to a core.

Detailed Description of the Preferred Embodiment

Throughout this specification the term "orientation" is intended to mean one or more of "dip", "roll", and "azimuth" of an apparatus, tool, core sample, borehole, or other structure in relation to which orientation data is required or desired.

Further, the expression "electronic orientation device" is intended to denote an electronic device or system that utilises electronic sensors and transducers such as but not limited to accelerometers, inclinometers, gyroscopes and magnetometers.

Throughout this specification the expression "downhole direction" is intended, unless the context clearly suggests otherwise, a direction that increases distance along the hole away from a collar of the hole. Thus for example in a hole drilled directly downwards in the ground the downhole direction is the same as the direction of gravitational acceleration. Whereas in an uphole such as one drilled in a back of a tunnel, the downhole direction is in a direction opposite to the direction of gravitational acceleration.

Throughout this specification the expression "uphole direction" is intended, unless the context clearly

suggests otherwise, a direction that decreases distance along the hole away from the collar of the hole. Thus for example in a hole drilled directly downwards in the ground the uphole direction is opposite the direction of gravitational acceleration. Whereas in an uphole such as one drilled in a back of a tunnel, the uphole direction is the same as the direction of gravitational acceleration.

Figures 1 and 2 illustrate an embodiment of a core orientation tool 10 in accordance with the present invention. The core orientation tool 10 is shown in association with an inner barrel assembly 11 which comprises a core tube 12 for receiving a core being cut by a core drill, and a backend assembly 14 that is attached to the core tube 12 for lowering and retrieving the core tube 12 from the core drill. The core tube 12 is of conventional construction while the backend assembly 14 is modified by the inclusion of an adaptor 16. The tool 10 is coupled at one end to the conventional core tube cap 18 of the backend assembly 14 with the adaptor 16 being used to couple an opposite end of the tool 10 to the remainder of the backend assembly 14. The tool 10 is in a known or measurable spatial relationship with the core tube 12. Further, as the core sample is rotationally fixed inside the core tube 12, at least shortly before and during a core breaking action, the orientation data relating to the core tube 12 can be related to the *in situ* orientation of the core sample.

The tool 10 comprises an electronic core orientation device or system 20 housed within a body 22 that is coupled to and between the core tube cap 18 and the adaptor 16. The electronic core orientation device 20 is configured to log one or more first indications of orientation of the tool (ie, core orientation) upon receiving of a trigger signal. To this end, the tool 10 includes a trigger system 24 that provides the trigger

signal upon detecting one or more downhole events associated with the operation of the core drill. These events may particularly relate to the core breaking function of the core drill and/or various sequences of events expected prior to core breakage.

The system 20 comprises multiple sensors and transducers for sensing various events and orientation data of the tool 10 and core drill. The sensors may comprise for example accelerometers, gyroscopes, physical switches, magnetometers, vibration sensors, inclinometers, inductive RPM sensors, flow sensors and pressure sensors. Some of the sensors and transducers send information to the trigger system that analyses the information to determine when to provide the trigger signal. Other sensors and transducers, notionally forming an orientation module 26, may be either in an idle state or continually providing data indicative of core and/or bore hole orientation, however these sensors and transducers are not activated and/or the orientation data is not logged until the trigger system 24 provides the trigger signal. It will be appreciated by those skilled in the art that some of the sensors and transducers that are used by the trigger system may also provide orientation data. The orientation system 20 may further comprise a transceiver 28 coupled to an antenna 30 to communicate with a hand-held computer or other like device. The function of this will be explained in greater detail later in the specification.

Embodiments of the tool 10 are able to log *in situ* orientation data relating to the core and the borehole from which the core is extracted at a time shortly before or at core breakage. This is done by arranging a trigger system 24 to issue the trigger signal upon sensing particular events or sequences of events that are expected to occur when a core is broken from the ground. One or more of the downhole events relate to physical events

arising from the motion of the tool 10 and indeed the core drill in the borehole. One of the telltale physical events of a core break is an uphole motion of the core drill and thus the tool 10. Accordingly the trigger system 24 may be configured to issue the trigger signal when sensors in the module 26 detect an uphole movement or acceleration or a change in direction of motion from a downhole direction to an uphole direction. While such motion is characteristic of a core break, other events or motions may also be sensed which increase the degree of confidence that the uphole motion is related to a core break. Examples of such events or motions include:

1. The backend assembly 14 being released at the collar of the borehole.

2. When the toe of the hole is below the water table, detecting the backend assembly 14 hitting the water table.

3. The backend assembly 14 contacting or hitting a landing ring within the core drill.

4. The commencement of drilling.

5. The cessation of drilling.

6. The breaking of the core itself.

7. An overshot hitting and latching onto the backend assembly 14.

For example, in addition to simply detecting an uphole motion of the tool 10 or the core tube 12 or core drill itself, the trigger system 24 may be arranged to issue the trigger signal upon the module detecting in sequence commencement of drilling, cessation of drilling and a

motion in an uphole direction. The sensing of the commencement and cessation of drilling may be via the use of vibration sensors in the module 26. It is known that during drilling as a core bit is bearing against rock, vibrations of known characteristics will be generated.

The trigger signal may be one of a plurality of trigger signals provided upon detection of different downhole events. That is a trigger signal may be provided when commencement of drill is detected, another when cessation of drilling is detected and another when an uphole motion of the tool 10 or drill is detected. Thus logging (recording) of data will commence prior to the breaking of the core. Additionally different orientation indications may be logged at different trigger signals. For example dip may be logged at when the trigger system detects drilling has stopped (e.g. detecting no rotation of the core drill following previously detecting the commencement of drilling; and core orientation may be logged upon the trigger system detecting a core lifter case gripping the core just prior to the core break.

The tool 10 and more particularly the electronic orientation system 20 comprises a memory device for storing logged data. The trigger signal may be considered to act as a pointer to identify the logged orientation data at the time the trigger signal(s) where provided so that the orientation data can be correlated to particular downhole event, particularly the core break.

Accordingly sensing a change in the characteristics of the vibrations would be indicative of the commencement and cessation of drilling. However this is not the only way in which the commencement and cessation of drilling may be sensed. As an alternate, sensors may be provided in the module 26 or trigger system 24 to sense the speed, direction or change in speed or direction of rotation of

the core drill. For example upon commencement of drilling, the sensor will detect rotation of the core drill, while on cessation of drilling the sensor will subsequently detect a change in the speed of rotation and more particularly a zero speed of rotation. Such a sensor may comprise an inductive RPM sensor, accelerometer or gyroscope having a component on or adjacent a rotating section of the backend assembly 14, such as for example on an uphole side of bearing 32 of the backend assembly.

Other possible variations for detecting the commencement and cessation of drilling include by detecting flow of fluid through or around the backend assembly 14. In this regard, fluid is pumped through or around the core drill and backend assembly during drilling with the flow being cut off when drilling ceases. Therefore detecting a change in the flow of water will also be indicative of the cessation of drilling. Also while uphole motion may typically be sensed by an accelerometer, other types of sensors including optical sensors or lasers may be used for sensing motion in an uphole direction.

A substantive benefit of the tool 10 over other core orientation devices that rely on the logging of time to correlate orientation data to a core is that the tool 10 does not require the use of timers by human operators and is therefore less susceptible to error. The above described embodiment of the tool 10 may be considered as a "drop and forget" sensor which will automatically log core orientation data shortly before or at the time of a core break.

The tool 10 may be further configured to provide borehole azimuth and vertical core orientation relative to azimuth. It is known to use gyroscopes to obtain azimuth information when logging boreholes. However gyroscope technology is not suitable for use in downhole core

orientation during the drilling process. The reasons for this include that the gyroscopes are prone to drift when operated for extended periods as would be required when lowering the gyroscope through the core drill; the inability for the gyroscope to maintain accurate orientation when exposed to sudden movements such as a shunt or vibration as typically would occur when dropping a backend assembly down a drill string; and, the need for the azimuth measurement to be made relative to a known reference point.

Notwithstanding the above limitations, an embodiment of the tool 10 may comprise a gyroscope 34 or similar device for logging azimuth and dip. This is enabled by the use of the trigger system 24 which will only trigger the gyroscope 34 to move from an off or idle state to a logging state at the same time as it supplies a trigger signal to the measurement module 26. Prior to the trigger system 24 providing the trigger signal, the gyroscope 34 is either off or in an idle state. Upon receipt of the trigger signal, the gyroscope 34 is activated to commence tracking changes in orientation.

As the inner barrel assembly 11 is being withdrawn from the core drill, the gyroscope 34 continues to tracking changes in orientation. Orientation of a collar of the borehole may be used as a known reference orientation. Thus changes in orientation since the issuance of the trigger signal can be related back to the collar orientation so as to enable determination of the azimuth of the tool 10 and the borehole at the toe of the hole substantially at the time of a core break. This in effect provides a single survey shot at the bottom of the hole. This data may be used to build an ongoing survey of the borehole for determining its path when combined with a measurement or estimate of the hole depth. This may be

determined by simply counting the number of rods in the core drill at each core run.

As the gyroscope 34 will only need to track changes in the orientation of the tool 10 after drilling has stopped, the need to track changes during the descent of the tool down the hole and during drilling is avoided. This substantially reduces the running time of the gyroscope therefore reducing the drift that may occur. It also obviates the need for the gyroscope to track changes in high vibration periods during drilling thus avoiding a significant loss of accuracy.

In the above embodiment, the tool 10 is used as a stand alone tool to obtain orientation data. In order to extract the data and relate the data to a core sample held within the core tube 12, the tool 10 may be used in conjunction with a core orientation system of the type described in Applicant's International application No. WO 2007/137356. In brief, the core orientation system in the abovereferenced publication comprises a combination of:

an electronic orientation device which may have some features common to the current device 10;

a core position indicator adapted for engagement with the core tube 12 when on the ground; and,

a remote unit such as a hand-held computer that communicates between the tool 10 and the core position indicator.

In short, the transceiver 28 in the tool 10 communicates via wireless communication with the hand-held computer which in turn transfers data to the core position indicator. More particularly, the tool 10 logs orientation data of a reference point on the core tube 12

relative to a first datum at the time the particular downhole event has occurred, ie, at or shortly before a core break. The reference point on the core tube need not be a physical marking. Once the core tube 12 is retrieved and placed in a stable position say on a core tray, the tool 10 is again operated to log orientation data of the same reference point on the core tube to a second datum. A rotational displacement σ from the first datum to the second datum is calculated by the hand-held computer and wirelessly communicated to the core position indicator. The core position indicator is then rotated about the core tube 12. When the core position indicator is moved to a position where it is rotated by the appropriate rotational displacement σ from the second datum, it emits a signal to indicate the position of the first datum.

The core position indicator also includes a guide in the form of a slat having an elongated slot for receiving a scribing or marking device such as a pencil. The forward most end of the slat extends over the front of a core lifter case 36 and a portion of the core extending from the core lifter case. The marker is then used to mark the core lifter case and/or core to signify the location of the core relative to the particular datum.

The core position indicator may be modified over and above that described in the above referenced application by the inclusion of a sensor to sense when a marker has been run along the slot to signify that a marking has been made on the core lifter case and/or core. The core position indicator and the hand-held computer can record how accurately an operator marks the core by comparing its position when marked to its required position. This accuracy of marking information can then be transferred back to the hand-held computer and integrated with the original orientation information. The information contained in the hand-held computer is transferable to a

removal medium so that all the information can be provided to the recipient of the core.

Alternately, the core position indicator may be arranged so as to prevent a user from marking the core until the core position indicator is correctly orientated. This may be achieved for example by having a moveable gate that slides across the slot to block the slot when the core position orientator is not in the correct orientation.

In one variation the trigger system may be modified to provide trigger signals on based on one or both of (a) one or more downhole events, and (b) effluxion of time.

The time triggers may comprise one or a combination of:

(a) a single trigger at a specified delay time relative to a time the device was initialized by an operator or triggered by a physical event;

(b) multiple continuous triggers at preset intervals commencing at a specified delay time relative to a time the device was initialized by an operator or triggered by a physical event and from which one or more data sets are selected.

The trigger system 24 may trigger the sensors in the module 26 to record one, or a combination of readings of orientation at a point/points in time:

(a) exactly when the trigger occurs;

(b) after some time delay;

(c) prior to the trigger by selecting a pre recorded reading where multiple readings are taken at predetermined intervals.

The trigger system 24 may cyclically provide trigger signals for a prescribe period of time after the first trigger is provided. For example trigger signals may be

provided every 10 seconds for a two minute period. Alternately, the electronic orientation device 20 may be arranged so that upon receiving a trigger signal, it logs the one or more first directional characteristics cyclically for a prescribed period of time, for example every 10 seconds for a 2 minute period.

Figures 3-6 illustrate various core orientation apparatuses 100 which comprise a combination of the core orientation tool 10 together with one or more secondary orientation devices. As described in greater detail below, one of the secondary orientation devices may be a core face orientation device which records the *in situ* orientation of the face of the core. Another secondary orientation device that may be incorporated into the apparatuses 100 is a bottom orientator which records the location of a zero gravity vector at the toe of the hole provided that the hole is inclined to the vertical. The secondary orientation devices may be mechanical or electronic.

In the embodiment of the apparatus 100 shown in Figure 3, the trigger system 26 is depicted as being contained in the common housing 22 with the remainder of the electronic system 20. However this need not be the case and the trigger system 26 may be physically separate from the tool 100 but in communication remainder of the electronic system 20 (for example by radio communication) to allow delivery of the trigger signals.

The trigger system 24 may provide trigger signals based on the same downhole events described in relation to the first embodiment.

This embodiment of the apparatus 100 comprises: a secondary orientation device which provides core face orientation and is in the form of a profile device 120;

and, body 122 having a downhole end 124 and an uphole end 126. The body 122 comprises a lock body 127, a latch body 128 and an anchor 130, which are described in detail hereinafter with reference to the embodiment shown in Figures 5 and 6. In the embodiment of Figure 3, the electronic orientation device 20 is located downhole of the body 122.

The device 120 may take the form of the face orientator as described in Applicant's above referenced International publication No. WO 07/109848. The device 120 comprises a substantially cylindrical body 132 having a plurality of internal axially extending holes 134 for seating respective pins 136. The pins 136 are held within the holes 134 with a degree of resilience so that if an axial force is placed on the pins 136 in the uphole direction, the pins 136 can slide within the body 132, but when the force is removed, the pins 136 maintain their relative position in their holes 134. The body 132 is also provided with a bearing scale 138 marked on its outer circumferential surface 140. The scale provides markings in five degree increments from 0° to 360°. The 0° mark is aligned with a positional reference mark 142 provided at a downhole end of a shaft 144 that extends into the electronic orientation device 20.

The mark 142 also provides a zero reference for the electronic orientation device 20 so that by coupling of the device 120 to the electronic device 20 both are keyed to the same zero reference.
The face orientator 120 provides a profile recording of a toe of the hole from which a core 112 is cut. It will be understood by those skilled in the art that the toe of the hole becomes an uphole face of the core 112. Typically the device 120 is constructed as a single use device that, upon extraction of the core, is removed from the apparatus 100 and is stored with the core 112. Prior to this

occurring, the scale 138 is marked with an angle denoting the orientation of the core relative to the zero degree mark on the scale 138. This marking may be obtained by transferring data from the electronic device 20 to the device 120 by an intervening hand held telemetry device (hand held computer) that interrogates the device 20 to obtain for example the tool face orientation data at the time the trigger signal is provided by the triggering system 26. This will provide for example a bearing in degrees referenced to the reference mark 142. This bearing can then be physically marked on the scale 138. For example if the tool face orientation was 35° relative to the marking 142, then an indelible mark can then be made on the 35° position on the scale 138.

Figure 4 illustrates a further embodiment of the apparatus 100. In this figure the features which are identical to those described with reference to Figure 3 are denoted by the same reference numbers. The substantive difference between the apparatus 100 shown in Figure 4 and that shown in Figure 3 is that the tool 10 in Figure 4 is located at the uphole end 126 of the body 122 and, an additional secondary orientation device in the form of a mechanical bottom orientator 146 is coupled between the downhole end 124 of the body 122 and the core face profile device 120. The bottom orientator 146 is provided with three balls 148a, 148b and 148c (hereinafter referred to in general as "balls 148") disposed within respective races 150a, 150b, and 150c (hereinafter referred to in general as "races 150"). Prior to the bottom orientator 146 being activated the balls 148 are free to roll within their respective races 150. Accordingly, by action of gravity, provided that the apparatus 100 is disposed in a borehole that is not absolutely vertical, the balls 148 will roll to the lowest point within their respective races. When the bottom orientator 146 is activated, the width of the races 150 is reduced so that the balls 148 are clamped in their

races. This prevents any further rolling of the balls and thus maintains the indication of the bottom of the hole.

The bottom orientator 146 is operated by the apparatus 100, and in particular the core face profile device 120, tagging the bottom of the borehole. The operation of the bottom orientator 146, the latch body 128 and the anchor 130 are described in detail in Applicant's above referenced applications WO 03/038232 and WO 2005/078232. Nevertheless a brief description of the operation of these components is provided below with particular reference to Figures 4 and 5.

A shaft 152, which is provided with the key mark 142, extends axially through the races 150 and up into the lock housing 127 and latch body 128. The device 120 is coupled to a downhole end of the shaft 152. The lock housing 127 includes a tubular extension 156 which has seats 157 on its outer surface for respective latches 158 that are pivotally coupled to the latch body 128 and can extend through windows 160 formed in the latch body 128. A shroud 159 is attached to a downhole end of the lock housing 127 and covers the bottom orientator 146. A recess 161 is also formed in the lock housing 127 between the seats 157 and the shroud 159. A pretensioned spring 162 is disposed about an upper end of the shaft 152 within the extension 156 and biases the shaft to in an uphole direction. A further spring 164 is held in a cavity between the latch body 128 and the extension 156 and acts to bias the extension 156 and thus the lock housing 127 in a downhole direction.

Another spring 166 acts between the latch body 128 and an anchor sleeve 168 of the anchor 130 biasing the sleeve 168 toward a shoulder 170 formed about an anchor body 172 of the anchor 130. A plurality of anchor balls 174 are retained within the anchor sleeve 168. The anchor balls

174 roll along an outer surface 176 of the anchor body 172. When the anchor sleeve 168 is butted against the shoulder 170 by the spring 166, the balls 174 extend radially beyond the anchor sleeve 168. In this position, the anchor balls 168 are held on a constant outer diameter portion 178 of the anchor body 172.

Moving in a downhole direction from the portion 176 the outer circumference of the outer body 172 is formed with a tapered portion 180 that leads to a circumferential recess 182. The anchor body 172 also has, at its down downhole end, a portion 184 of a first constant inner diameter, then a contiguous tapered portion 186 that has an increasing inner diameter, and which then leads to a further portion 188 having a constant inner diameter greater than the inner diameter of the portion 184.

A trigger seat 190 is attached to a uphole end of the shaft 152 and a plurality of trigger balls 192 are each seated partially in a circumferential groove 194 formed in the trigger seat 190 and in holes 196 formed in an uphole end of the extension 156.

The apparatus 100 is loaded into a downhole end of a core tube 12 by first inserting the end provided with the tool 10. Eventually the latch dogs 158 abut a downhole end of the core tube 12 preventing further insertion of a tool 100. During the insertion, the anchor body 168 slides axially away from the shoulder 170 so that the anchor balls 174 roll along the tapered portion 180 and thus move radially inward. Once insertion of the apparatus 100 has been ceased by abutment of the latches 158 with the downhole end of the core tube, the spring 166 pushes the sleeve 168 in a uphole direction causing the anchor balls 174 to commence to ride up the tapered length 180 to a position where they extend radially outward from the sleeve 168 to an extent where they bear against an inner

surface of the core tube 12. This effectively locks the apparatus 100 to the core tube 12 preventing it from falling out. The core tube 12 is then lowered into a core drill 193 via a conventional backend and wire line or other insertion method, with the core drill being suspended above the toe of the borehole. With the core tube correctly seated within the core drill, the core face profile device 120 extends from the shroud 159 and a drill bit 195 coupled to a downhole end of the core drill 193. During this time, the orientation balls 148 are free to roll within their races 150.

The core drill is then lowered onto the toe of the hole resulting in the pins 136 sliding axially within the cylindrical body 132 to provide a profile of the toe of the hole.

As the core drill is further lowered, prior to the commencement of drilling, an end of the shroud 59 will eventually be brought into contact with the toe of the hole. Now, further lowering of the core drill results in the extension 156 sliding axially inward relative to the latch body 128 in a uphole direction compressing the spring 164. Eventually, the trigger balls 192 will roll outwardly along the tapered portion 186 to the portion 188 of the anchor body 172. When this occurs, the trigger balls 192 are able to move outwards in a radial direction and disengage from the groove 194 in the trigger seat 190. This releases the spring 162 allowing it to push the trigger seat 190 and thus the shaft 152 in an uphole direction relative to the extension 156. This results in a clamping of the orientation balls 148 within their races 150.

Continued lowering of the core drill onto the toe of the hole results in the seats 157 sliding from under the latches 158 so that the recess 161 underlies the latches

58. The latches 158 are now free to rotate inwardly thereby disengaging the apparatus 100 from the downhole end of the core tube 12.

The axial motion of the shaft 152 may be used to activate a switch such as, but not limited to, a microswitch, a Hall Effect switch, an optical switch or a pressure switch, which may be considered as forming part of the trigger system, to provide a trigger signal for the electronic orientation device 20. The electronic orientation device 20 can then log data relating to the orientation of a tool 10, the borehole in which it resides, and/or the core 112. The logging of information by the electronic device 20 may occur at a predetermined frequency for a predetermined period of time. For example the electronic orientation device/system 20 may log orientation data every 10 seconds for a two minute period after receipt of the initial trigger signal.

The electronic orientation device 20 may be arranged so that the logging of indications of orientation occur only when trigger signals are received from both motion of shaft 152 and at least one other sensor or transducer of the trigger system 24.

The indication of orientation provided by the core face profile device 120 and bottom orientator 146 can be transferred to the core 112 in a manner described in Applicant's above referenced Australian patent application no. 2006901550 using template 198 as depicted in Figure 7. Template 198 comprises a pair of parallel lines 200 for location on opposites sides of the orientation balls 148, and a pointer line 202 that extends parallel with an centrally between the tram lines 200. An elongated slot 204 is cut in the template 198 and has one edge 206 in alignment with the pointer line 202. The slot 204 extends over the scale 138 on the body 132 as well as over a

portion of the core sample 112. An operator can use a marker such as a pen or pencil to draw line segments 208a along the edge 206 from the body 132 across the scale 138 and 208b along the core 112. Indication of orientation logged by the electronic orientation device 20 may be obtained and marked on the core 112 in the same manner as described in Applicant's above referenced Australian application no. 2006902873.

The provision of both the tool 10 and the mechanical orientation device 146, as depicted in Fig.4, also enables auditing of the apparatus 100 to provide a degree of confidence in the orientation data obtained therefrom. This arises because embodiments where there is both the electronic orientation device 20 and one or more mechanical orientation devices 146, a comparison can be made between the same indications of orientation obtained from each of the devices. For example if bottom of hole indications provided by the separate devices are within a acceptable tolerance range (e.g. up to 5°) a high degree of confidence is provided that each of the devices 20 and 146 is providing reliable indications of orientation. However, if the devices give indications that differ more than an acceptable range, potential errors can be flagged on site to enable corrective action.

The combination of the core tube 12 and the core orientation tool 10 forming the apparatuses shown in Figures 3-6 comprise what is believed to be a unique core retrieval system in that the electronic orientation device 20 is, at least at the time of deployment, located at a downhole or front end of the core tube 12. More particularly, as will be appreciated from the above description, the apparatus 100 being at the front or down hole end of the core tube 12 is physically close to the core sample 112 at the time, or one of the times, at which the electronic orientation device 14 logs orientation data

of the tool 100. It is believed that this may give rise to higher accuracy in the orientation data recorded than other systems in which electronic orientation devices are located at a backend of the inner core tube, i.e. between an uphole end of the inner core tube and an overshot. In this regard, inner core tubes typically come in lengths of three or six metres.

It is envisaged that various embodiments of the tool 10 may perform self checks and provide users with information regarding the status of the tool 10. Status messages may include one or a combination of low battery power, communications error, system faults. The tool 10 may also collect and process data so as to provide users with a measure of the accuracy and reliability of the recorded orientation data. The data collected by the tool 10 to provide orientation information may be analysed using statistical measures of its accuracy. Log data may be analysed to identify the presence of any movement during the logging of orientation data. The direction of motion may also be determined and provided to a user. These self checks may be beneficial to identify surface requirements. In particular the indication of movement during logging may be beneficial in identifying improper operation of the tool 10 and thus flag the need for training or retraining of operators.

For example one can analyze data from the sensors to determine whether the core drill was rotating and/ subject to excessive vibration at the time of a core break. Such events, particularly the rotation, will decrease the reliability of the orientation data. The tool 10 would typically comprise three accelerometers to provide acceleration data about the X, Y and Z axes respectively. Rotation of the core drill at the time of the core break would be indicated by readings from these accelerometers.

More particularly the tool 10 may provide the operator with information regarding the proper operation of its components parts and systems. If a component or system fails the tool 10 could report the failure to the operator via the handheld control unit. If the failure occurs or is detected while the tool 10 is down a bore hole it can be reported to the operator via the handheld control unit ounce the tool has been recovered to the surface.

Further to the above operation the tool 10 could also be capable of performing a complete self check that verifies the correct operation of the entire system. This self diagnostics could be run on demand by an operator or automatically when the operator is preparing the tool for a core run (being run down a bore-hole to perform its function). In this way a faulty tool would not be used for a core run and result in a failed orientation.

The tool 10 may also be able to provide information to the operator regarding the certainty of a provided orientation measure. The certainty of a orientation measure can be determined by analysing the tools sensor input before during and after the orientation measure is made. When analysed the sensor data may reveal that there was an unwanted environmental condition present when the orientation measure was made. The unwanted environmental condition could be motion in the form of a linear movement, rotation or vibration. It could also be some other environmental condition such as a high or low temperature. The results of the analyses could be reported to the operator in one or a combination of the following ways:

1. By providing an indication of the source of unwanted environmental condition.

2. By associating the unwanted environmental condition to a known down-hole event that should not have occurred and providing the event to the operator.

3. By providing a calculated measure of the orientations certainty from the analysed sensor data. For example a scale of 1 to 5 could be employed where 1 is a certain orientation and 5 is a very uncertain orientation (failed). The certainty of orientations could then be provided using this scale.

The information provided by the tool in the above ways will be useful in identifying procedural errors made by the operators of the tool. For example if the core drill was spinning when the orientation was measured the tool 10 would report that the orientation is uncertain because rotation was detected during the orientation. It could also report that the likely cause of the rotation was that the core drill was spinning. In future the operator will know to ensure that the core drill is not spinning when the orientation is being measured. Similarly if the core drill was being raised or lowered when the orientation was measured the tool 10 could provide a relevant report to the operator.

By providing feedback regarding device faults and the certainty of the orientations when something goes wrong the operator will be fully informed as to the cause. Thus operator error can be discerned from tool failure/error. These reports can also be made available to supervisors or managers via the hand held control device or when the data is exported to an external memory device or laptop to assist them in maintaining equipment or attending to training issues.

Now that various embodiments of the present invention have been described in detail it will be apparent to those skilled in the relevant arts that numerous modifications and variations may be made without departing from the basic inventive concepts. For example, a mechanical orientation device 146 is described which utilises three orientation balls 148. However in an alternate variation,

this orientation device may comprise only a single orientation ball. In addition or alternately, the mechanical orientation device may include a washer that is indented with a mark representative of the location of the bottom of the hole such as described in Applicant's international publication no. WO 03/038232. Embodiments of the invention may also include in addition or as an alternate to the mechanical orientator 146 a mechanical inclinometer an example of which is described in Applicant's above referenced international publication no. WO 03/038232.

As an alternative to the Van Ruth (ie pin type) face orientator 120, core face orientation may be obtained by other devices including, marker pencils and scribes, optical or electromagnetic imaging and distance measuring devices. The logging of azimuth can be achieved using any known electronic system when measured by the electronic orientation device 20, or any known mechanical system when measured by a mechanical orientation device 146. These include for example the use of magnetometers to sense magnetic direction when used in conjunction with non-magnetic drilling equipment or if attached in a position outside the drill string to avoid magnetic interference. Azimuth may also be recorded using gyroscope type sensors to measure inertial change in position from a known reference point; or by use of a gyrocompass or north seeking gyroscope type sensor.

All such modifications and variations together with others that would be obvious to a person of ordinary skill in the art are deemed to be within the scope of the present invention the nature of which is to be determined from the above description, and the appended claims.

The claims defining the invention are as follows:

1. A core orientation tool for providing an indication of *in situ* orientation of a core sample extracted from a borehole by a core drill the tool comprising:

an electronic orientation system coupled with the core drill, the electronic orientation system configured, upon receiving a trigger signal, to log one or more first indications of orientation of the tool; and,

a trigger system that provides the trigger signal upon detecting one or more downhole events associated with operation of the core drill.

2. A core orientation tool for providing an indication of *in situ* orientation of a core sample extracted from a borehole by a core drill the tool comprising:

an electronic orientation system coupled with the core drill, the electronic orientation system configured, upon receiving a trigger signal, to log one or more first indications of orientation of the tool; and,
a trigger system that provides the trigger signal upon one or both of (a) detecting one or more downhole events associated with operation of the core drill, and (b) effluxion of time.

3. A core orientation tool for providing an indication of *in situ* orientation of a core sample extracted from a borehole by a core drill the tool comprising:

an electronic orientation system coupled with the core drill, the electronic orientation system configured to log one or more first indications of orientation of the tool; and,

a trigger system that provides a trigger signal upon detecting one or more downhole events associated with operation of the core drill; and,
wherein tool is configured to associate the one or more first indications of orientation with the trigger signal.

4. The core orientation tool according to any one of claims 1-3 wherein trigger signal is one of a plurality of trigger signals provided by the trigger system.

5. The core orientation tool according to claim 4 wherein the tool is configured to log different first indications of orientation upon receipt of different trigger signals.

6. The tool according to any one of claims 1-5 wherein the one or more downhole events comprise respective physical events arising from motion of the tool or the drill in the borehole.

7. The tool according to claim 6 wherein the motion comprise one or a combination of:

(a) motion in an uphole direction;

(b) a change in motion from motion having a linear component in a downhole direction to motion having no linear component;

(c) a change in motion from motion in a downhole direction to motion in an uphole direction;

(d) a change in motion from no linear motion to motion in an uphole direction;

(e) a change in characteristics of vibration motion on the tool or drill arising from the cessation or commencement of drilling;

(f) a change in speed of linear motion of the tool;

(g) any change in velocity (speed and/or direction of movement); and,

(h) a change in the rate or direction of rotation around the tool's longitudinal, lateral or normal axis.

8. The tool according to any one of claims 1-7 wherein the trigger system is configured to provide the trigger signal upon detecting a predetermined event or sequence of downhole events.

9. The tool according to claim 8 wherein the sequence of downhole events comprise a cessation of drilling followed by motion of the tool in an uphole direction.

10. The tool according to claim 9 wherein the sequence of downhole events further comprise commencement of drilling prior to the cessation of drilling.

11. The tool according to claim 10 wherein the sequence of downhole events further comprise one or more of:

(a) detecting contact of a backend assembly to which the tool is coupled hitting a landing ring in the core drill;

(b) detecting the backend assembly hitting a water table in a drilling operation where the drill is operated in the borehole below the water table;

(c) detecting release of the backend assembly from a wire line when initially inserting a core tube into the core drill;

(d) detecting the tool or core drill tagging a toe of the bore hole;

(e) an overshot hitting and latching onto the backend assembly;

(f) retrieval of the backend assembly from the drill hole; and,

(g) a change in the flow of fluid through or around the backend assembly.

12. The tool according to any one of claims 1-11 wherein the electronic orientation system further comprises an electronic azimuth measuring device, wherein the electronic azimuth measuring device operates to log azimuth upon receiving the trigger signal.

13. The tool according to claim 12 wherein the electronic azimuth measuring device is configured to operate in an idle state prior to receipt of the trigger signal.

14. The tool according to claim 13 wherein the electronic azimuth measuring device comprises an electronic gyroscope.

15. A core retrieval system for a core drill comprising:

a core tube having an uphole end and a downhole end, the downhole end provided with an opening for receiving a core sample cut by the core drill; and,

a core orientation tool in accordance with any one of claims 1-14, wherein the core orientation tool is coupled to the core tube at a location uphole of the downhole end of the core tube.

16. The core retrieval system according to claim 15 further comprising a backend assembly coupled to the uphole end of the core tube and wherein the core orientation tool is attached to the backend assembly uphole of the uphole end of the core tube.

17. A method of logging *in situ* orientation of a core sample extracted from the ground by a core drill comprising:

coupling an electronic core orientation device in a known spatial relationship to a core sample cut by the core drill;

configuring the electronic core orientation device to log one or more indications of orientation of the device upon receipt of a trigger signal; and,

providing the trigger signal upon detecting one or more downhole events associated with the operation of the core drill.

18. The method according to claim 17 wherein the downhole events are indicative of a, or an imminent, core break.

19. The method according to claim 17 or 18 wherein detecting of the one or more downhole events comprises detecting an uphole motion of the device.

20. The method according to claim 19 wherein the detecting of the downhole event comprises detecting a cessation of

drilling prior to detecting the uphole motion of the device.

21. The method according to claim 20 wherein the detecting further comprises detecting commencement of drilling prior to detecting cessation of drilling.

22. The method according to claim 21 wherein the detecting comprise detecting a cessation of downhole movement of the device prior to detecting the commencement of drilling.

23. The method according to any one of claims 17- 22 wherein the configuring comprises configuring the electronic core orientation device to determine azimuth.

24. The method according to claim 23 further comprising withdrawing the tool after the trigger system provides the trigger system and operating the electronic core orientation device to track changes in orientation until the tool reaches a collar of the borehole.

25. A core orientation apparatus for providing an indication of orientation of a core sample extracted from a borehole by a core drill the apparatus comprising:

a core orientation tool according to any one of claims 1-14 and,

one or more secondary orientation devices which provide one or more second indications of orientation of the core or borehole, wherein the electronic orientation device is in a known rotational position relative to the one or more secondary orientation devices.

26. The apparatus according to claim 25 wherein the secondary devices comprise one or both of (a) a core face orientation device which records orientation of an uphole face of a core sample; and (b) a bottom of hole recording device.

27. The apparatus according to claim 25 or 26, wherein the tool comprises a body having a downhole end and an uphole end, wherein a the one or more secondary orientation devices are located downhole of the body and the electronic orientation device is located between the secondary orientation devices and the downhole end of the body.

28. The apparatus according to claim 25 or 26, wherein the tool comprises a body having a downhole end and an uphole end, wherein the one or more secondary orientation devices are located downhole of the body and the electronic orientation device is located uphole of the body.

29. The apparatus according to claim 27 or 28, wherein the body is provided with a positional reference for the first and second indications of orientation, and one or more keys for keying the electronic orientation device and the one or more secondary orientation devices to the position reference.

30. A core retrieval system for a core drill comprising:

an inner core tube having an uphole end and an opposite downhole end provided with an opening for receiving a core cut by the core drill; and,

a core orientation tool coupled to the inner core barrel and movable inside the inner core tube in an uphole direction by abutment with the core, wherein the core orientation tool accords with any one of claims 1-14.

31. The core orientation tool according to any one of claims 1-14 wherein the tool is configured to analyse outputs from sensors and transducers in the trigger system that detect the downhole events, to verify correct operation of the tool.

32. The core orientation tool according to claim 31

wherein the tool is configured to analyse outputs from sensors and transducers in the trigger system that detect the downhole events to verify that the core drill was stationary when a core break operation was performed.

33. The method according to any one of claims 17-24 comprising analyzing outputs from sensors and transducers in the trigger system that detect the downhole events, to verify correct operation of the tool.

34. The method according to claim 33 wherein the analyzing comprises analyzing the outputs to verify the core drill was stationary at when a core break operation occurred.

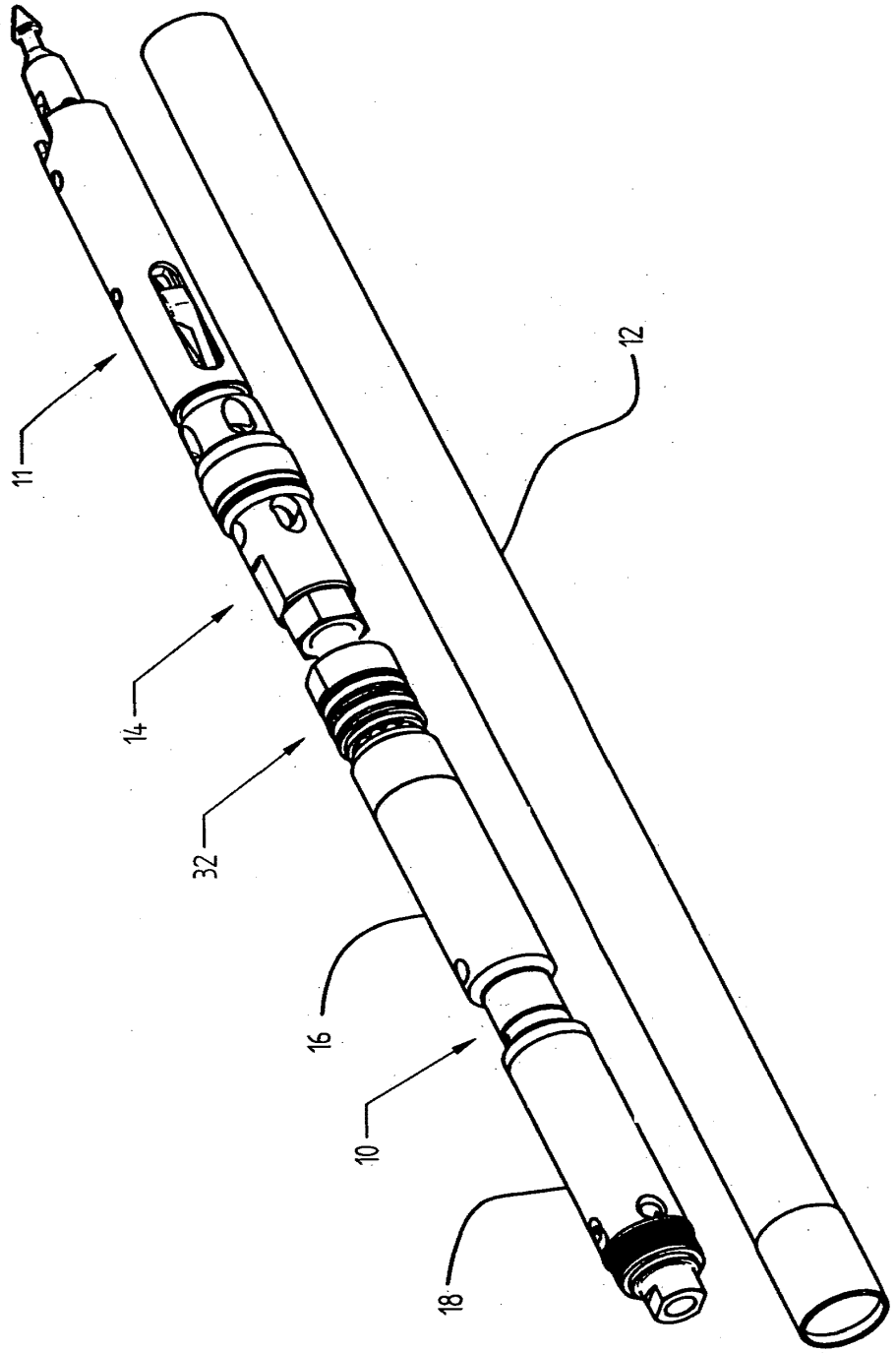


Figure 1

Figure 2

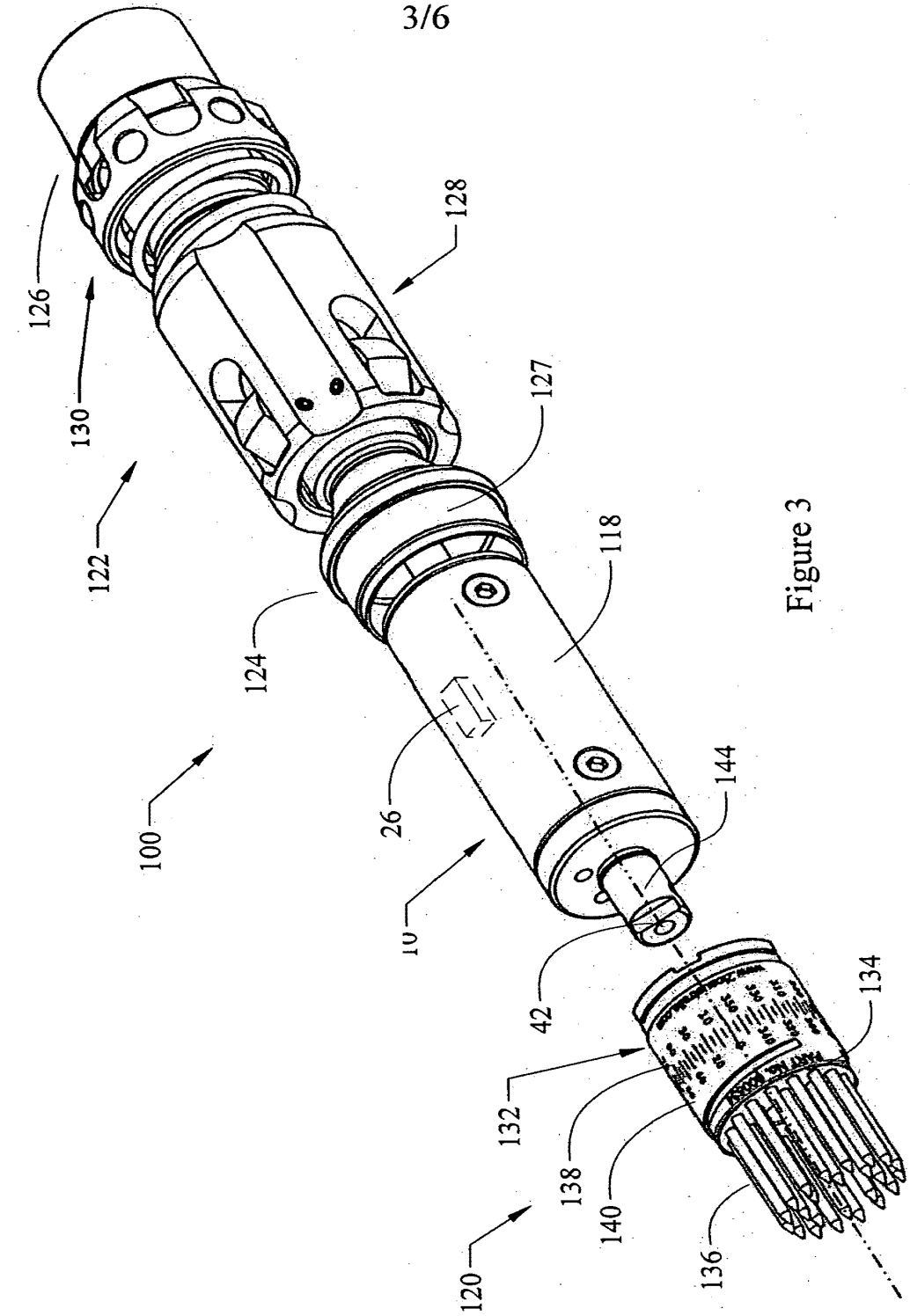

126
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Figure 3

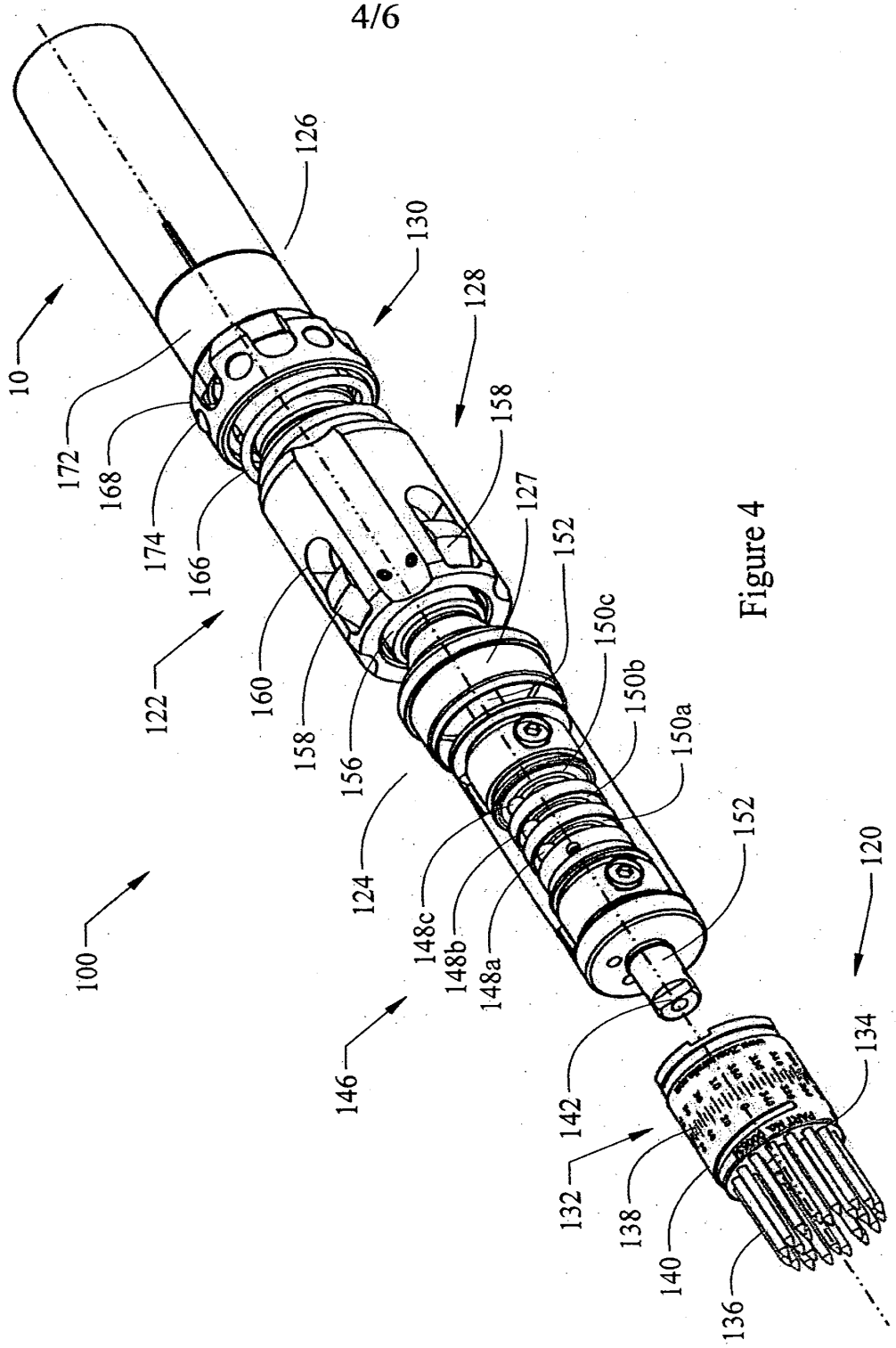

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Figure 4

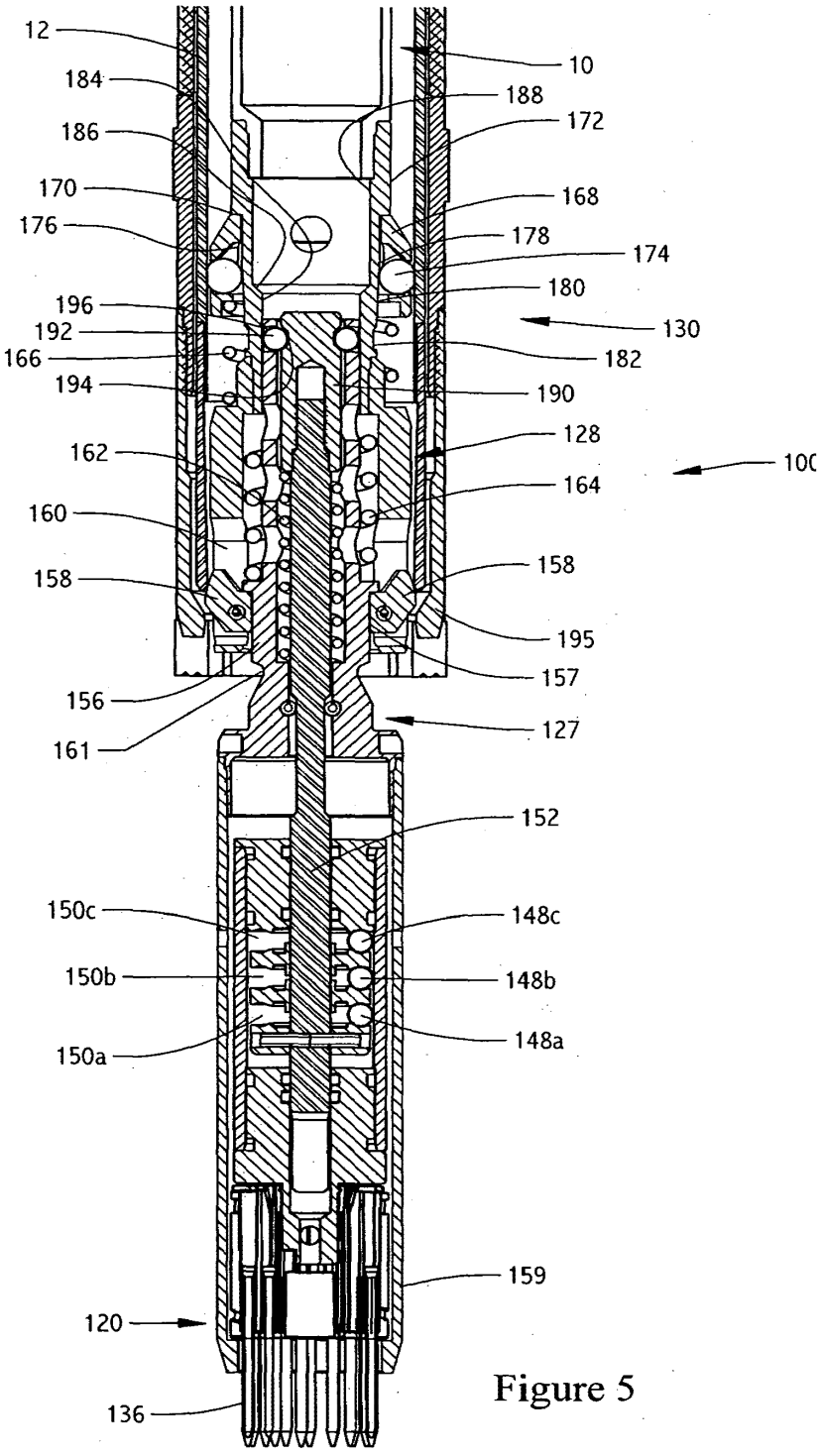

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150c
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148c
148b
148a
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Figure 5

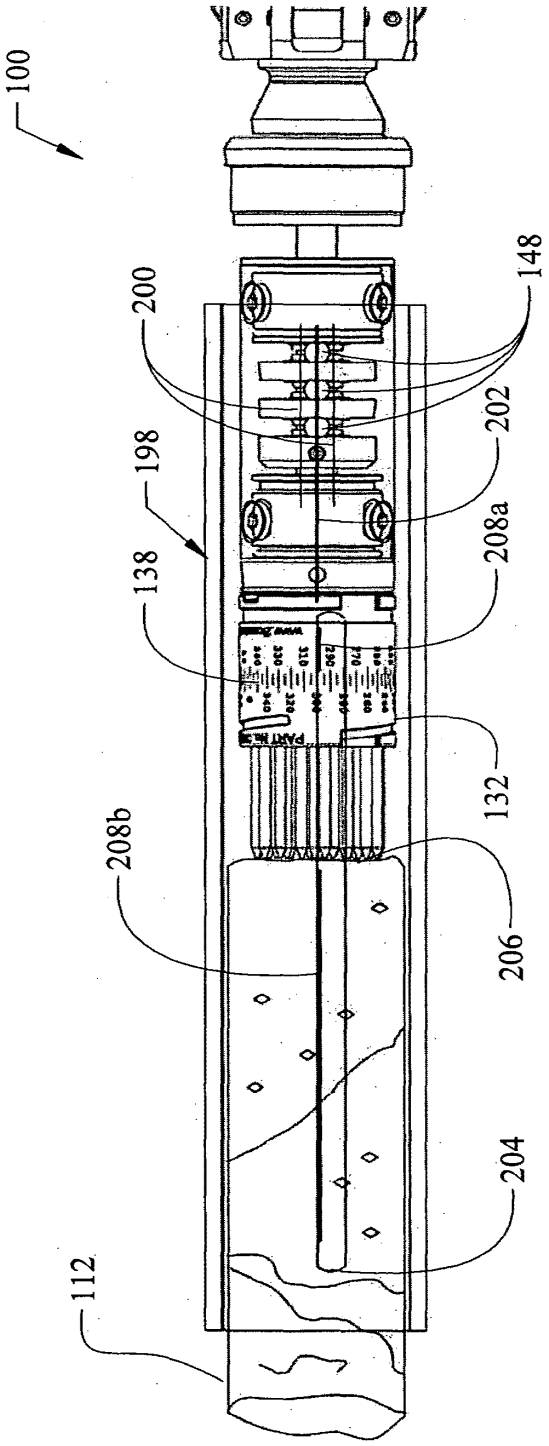


Figure 6

INTERNATIONAL SEARCH REPORT

International application No.
PCT/AU2008/000395

A. CLASSIFICATION OF SUBJECT MATTER

Int. Cl. ***E21B 25/16*** (2006.01) ***E21B 49/02*** (2006.01)

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)

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

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
Dwpi: E21B 25/16, 49/02 with keywords (trigger+, sens+, signal+, azimuth+, gyroscop+, generat+, activate+, detect+, electronic+)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2006/024111 A1 (AUSTRALIAN MUD COMPANY LTD) 9 March 2006 Page 10, line 18 – page 24, line 25	1-10, 12-25, 30 and 31-34
X	WO 2006/058377 A1 (CORETRACK PTY LTD) 8 June 2006 Page 3, line 9 – page 5, line 15; claims 1-9 and Figures 1-4	1-10, 12-25, 30 and 31-34
X	Derwent Abstract Accession No. 97-242837/22, Class X25, JP 09078975 A (NIPPON SHINKO KK) 25 March 1997	1-10, 12-25, 30 and 31-34
A	US 6006844 (PUYMBROECK et al) 28 December 1999 The whole document	1-34

[X] Further documents are listed in the continuation of Box C [X] 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	Date of mailing of the international search report
05 May 2008	17 MAY 2008
Name and mailing address of the ISA/AU AUSTRALIAN PATENT OFFICE PO BOX 200, WODEN ACT 2606, AUSTRALIA E-mail address: pct@ipaustralia.gov.au Facsimile No. +61 2 6283 7999	Authorized officer **LEOPOLD FILIPOVIC** AUSTRALIAN PATENT OFFICE (ISO 9001 Quality Certified Service) Telephone No : (02) 6283 2105

Form PCT/ISA/210 (second sheet) (April 2007)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/AU2008/000395

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	CA 2456506 A1 (SCOTT) 3 January 2005 The whole document	1-34
A	WO 2005/085584 A1 (2iC AUSTRALIA PTY LTD) 15 September 2005 The whole document	1-34

Form PCT/ISA/210 (continuation of second sheet) (April 2007)

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.
PCT/AU2008/000395

This Annex lists the known "A" publication level patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent Document Cited in Search Report		Patent Family Member					
WO	2006024111	AU	2005256104	AU	2006100113	CA	2559030
		US	2007282533				
WO	2006058377	AU	2005312340	EP	1817480		
JP	9078975						
US	6006844	BE	1011414	CA	2158903	DE	19745947
		GB	2293395	GB	2318372	NO	953755
		NO	974786	US	5568838		
CA	2456506						
WO	2005085584	AU	2005219460	CA	2559085		

Due to data integration issues this family listing may not include 10 digit Australian applications filed since May 2001.

END OF ANNEX

(12) UK Patent Application (19) GB (11) 2 243 173 (13) A

(43) Date of A publication 23.10.1991

(21) Application No 9106537.5

(22) Date of filing 27.03.1991

(30) Priority data
(31) 500148 (32) 27.03.1990 (33) US

(71) Applicant
Seafloors Engineers Inc

(Incorporated in the USA - Texas)

2500 Central Parkway, Suite M, Houston, Texas 77092, United States of America

(72) Inventors
Wayne B Ingram
Byron W Porter

(74) Agent and/or Address for Service
Kilburn and Strode
30 John Street, London, WC1N 2DD, United Kingdom

(51) INT CL[5]
E21B 25/00, E02D 1/00

(52) UK CL (Edition K)
E1F FHA FHA1 FHA2

(56) Documents cited
EP 0083141 A2 **US 4770030 A** **US 4601354 A**
US 4499956 A **US 4499955 A**

(58) Field of search
UK CL (Edition K) **E1F FHA**
INT CL[5] **E02D, E21B**

(54) Self-contained apparatus and method for determining the static and dynamic loading characteristics of a soil bed

(57) The invention comprises an apparatus and method for sampling and determining the dynamic loading characteristics of a soil bed. The apparatus is specially adapted to withstand the extreme pressures of deep water applications. In operation, a drill string presses a sample tube 23 into a soil bed at an uncontrolled rate resulting in a variable penetration rate. The apparatus has a self-contained data acquisition system that measures and records, as a function of time, the force exerted on the sampling apparatus and the depth of penetration as the drill string presses the sampling apparatus into the soil bed.

Data is provided that enables the user to determine the static soil characteristics (e.g., shear strength and stress-strain characteristics) and the dynamic loading characteristics of the soil bed. The apparatus captures a sample of the soil for laboratory analysis.

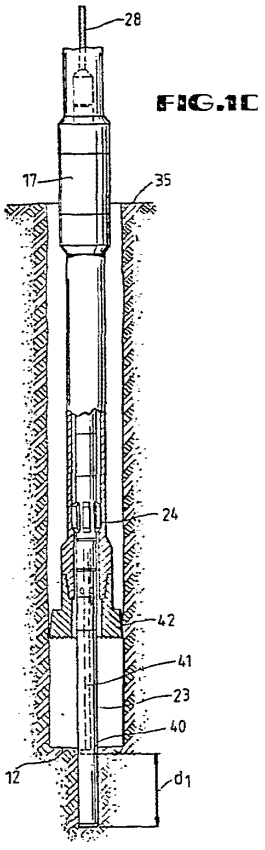


FIG.1C

At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

GB 2 243 173 A

FIG.1A

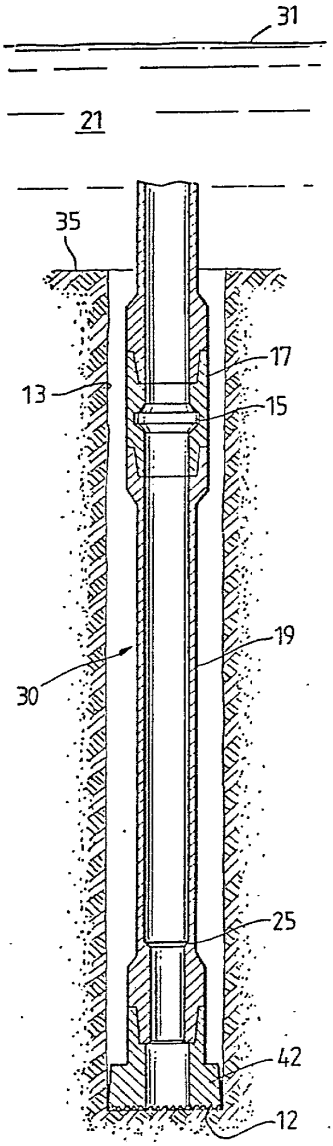


FIG.1B

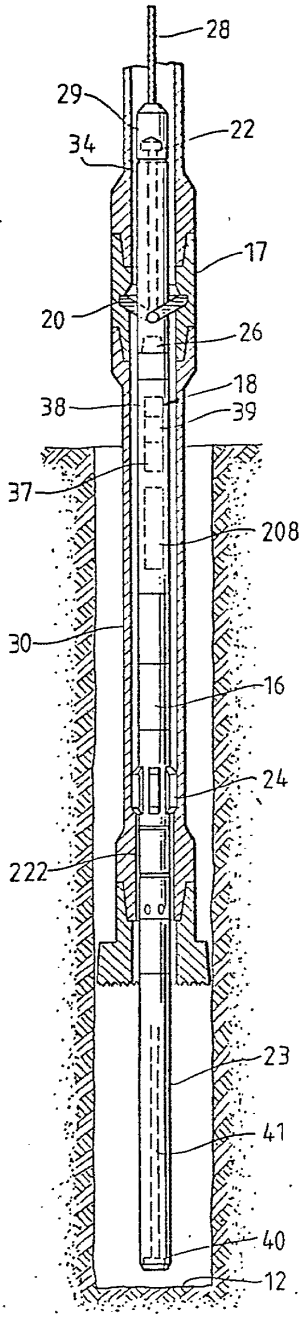


FIG.1C

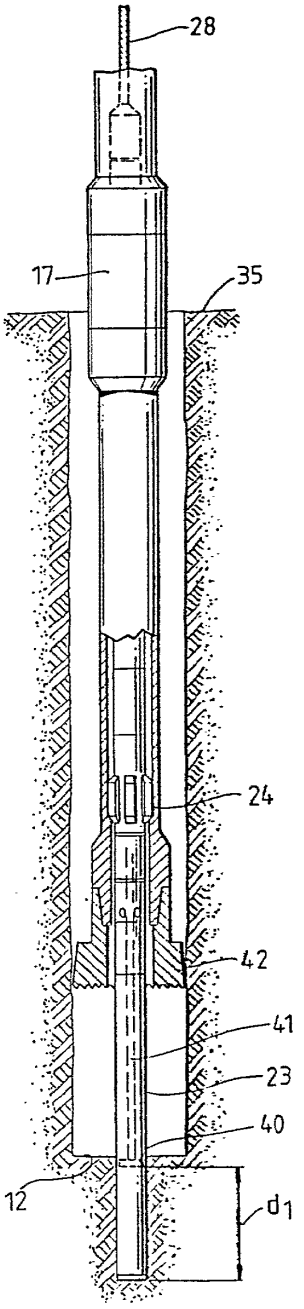


FIG.1D

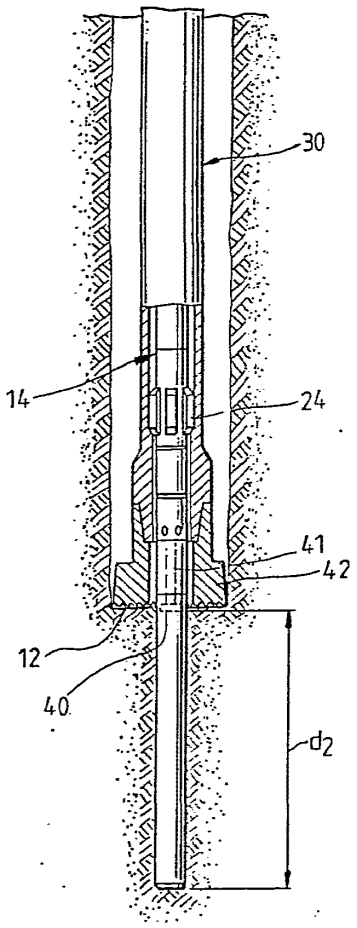
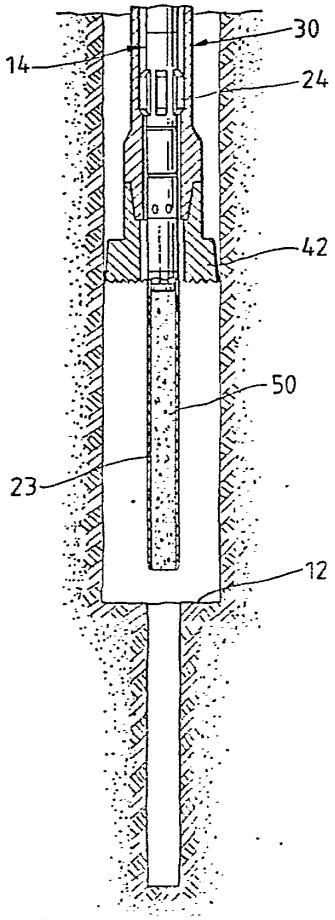


FIG.1E



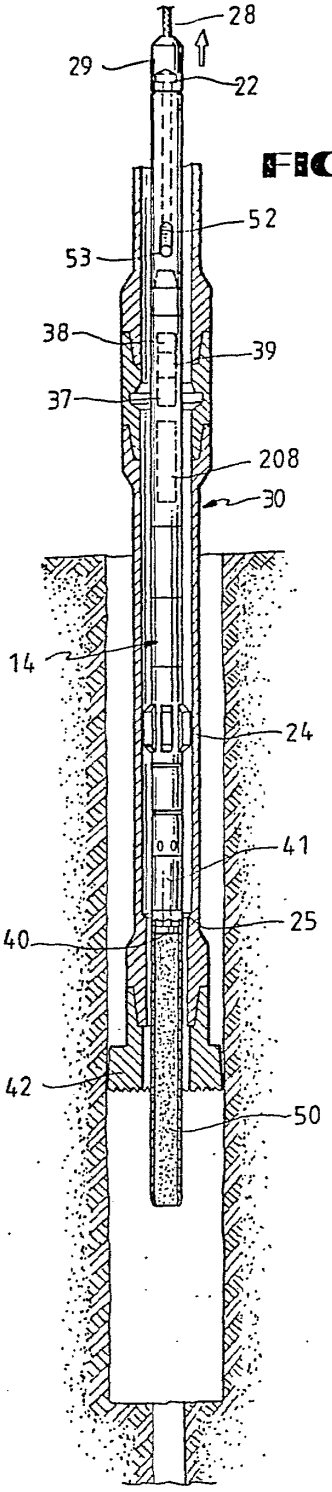

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FIG.1F

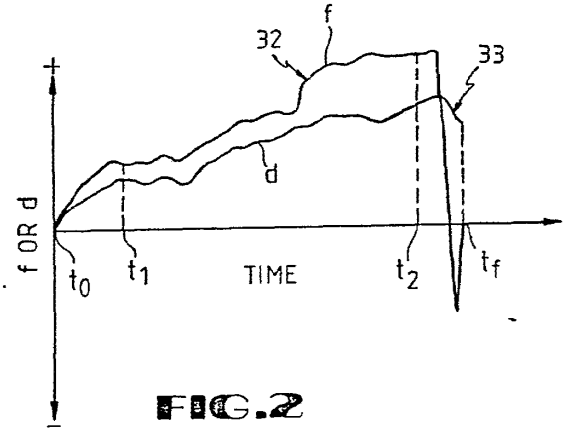

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d
f OR d
t_0
t_1
TIME
t_2
t_f

FIG.2

FIG.3A

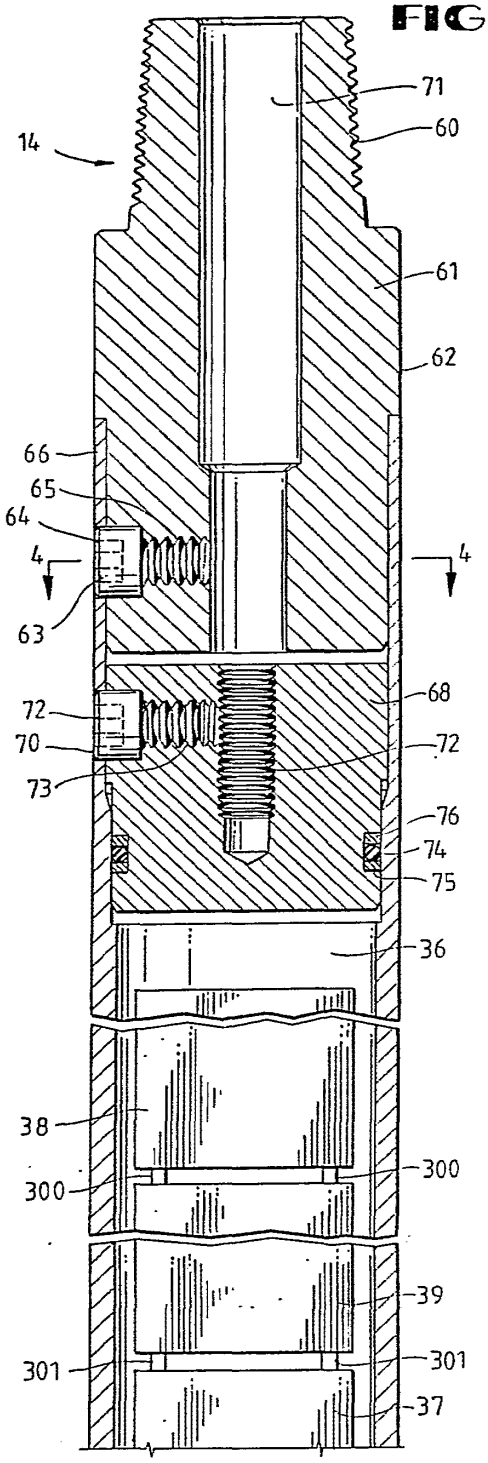

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FIG.3B

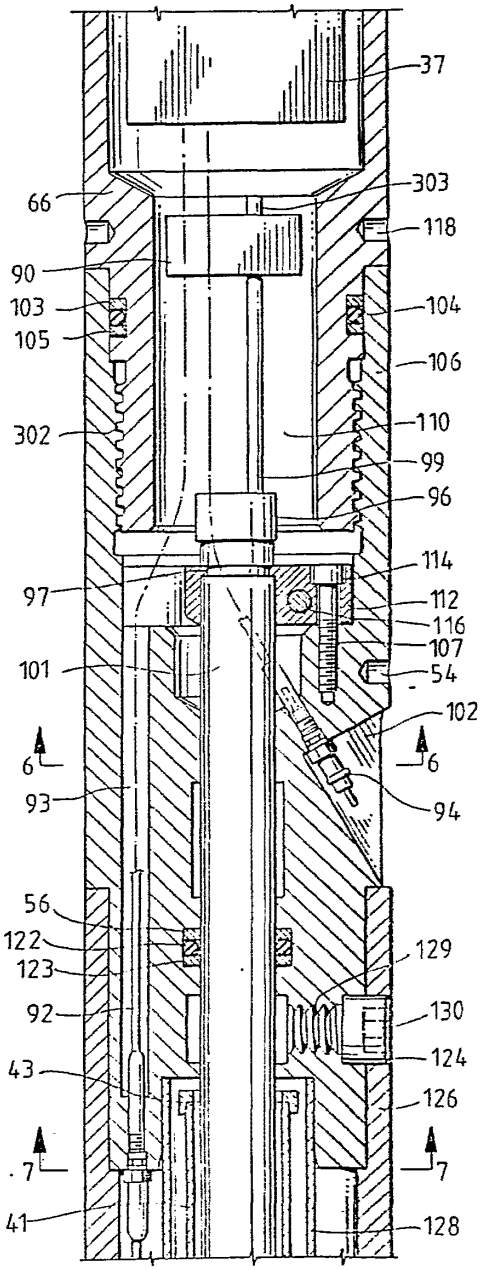

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FIG.3C

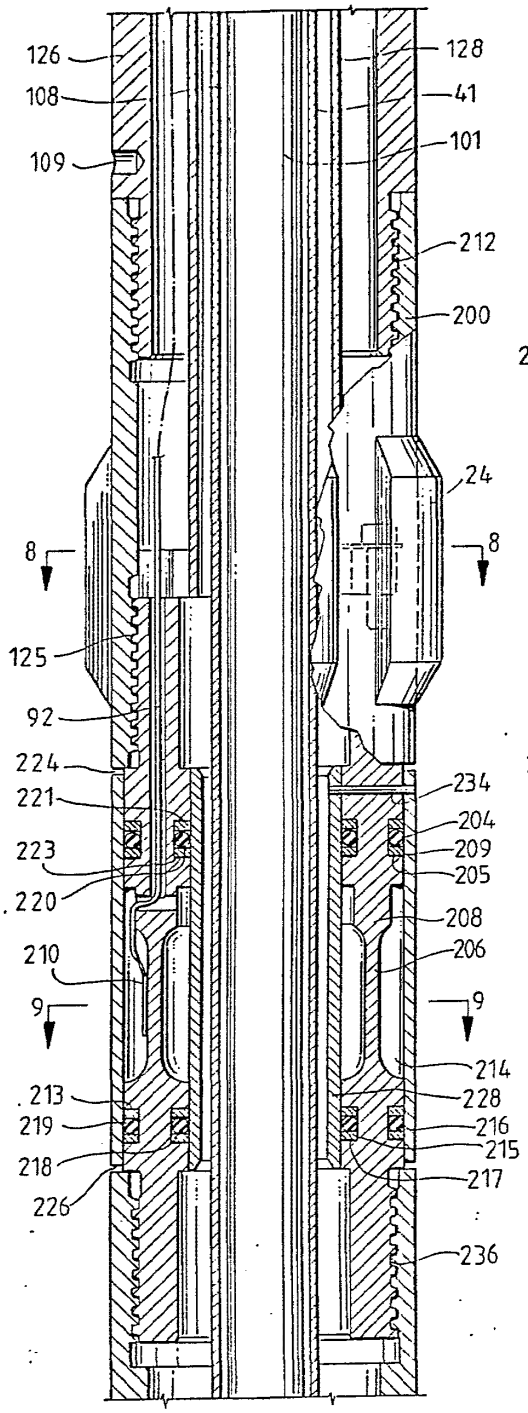

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FIG.3D

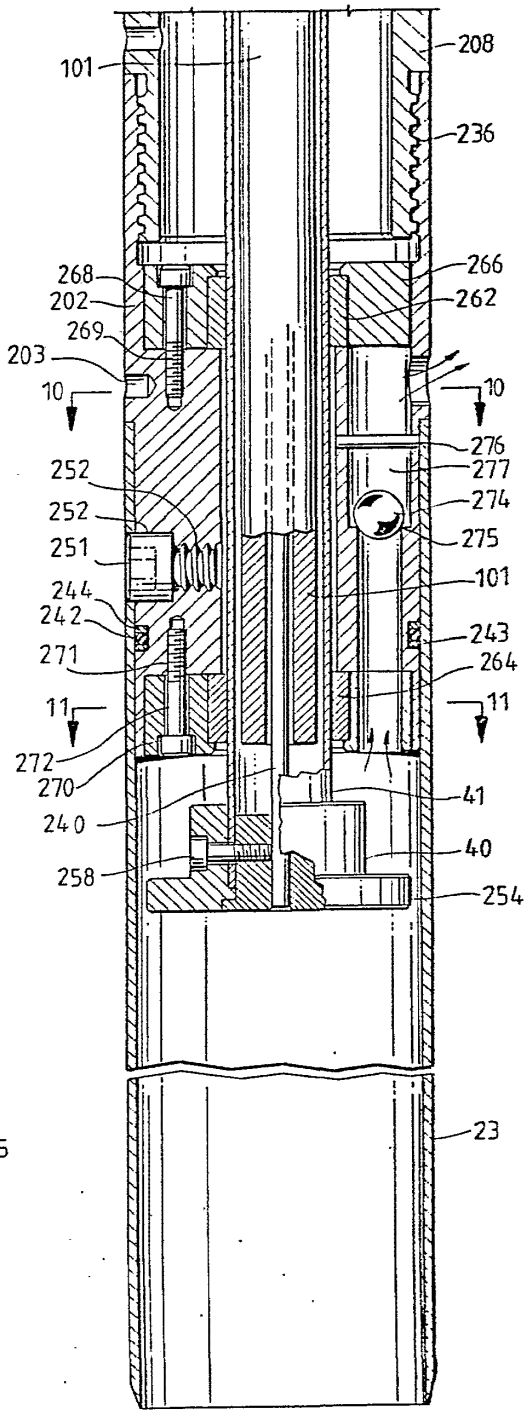

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FIG.4

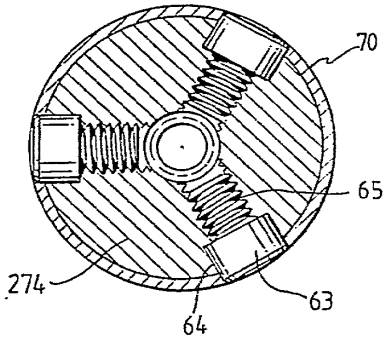
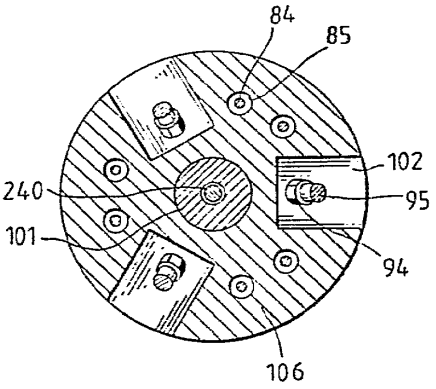


FIG.6



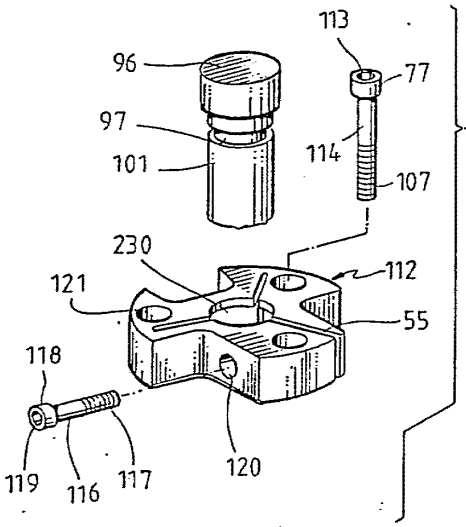


FIG.5

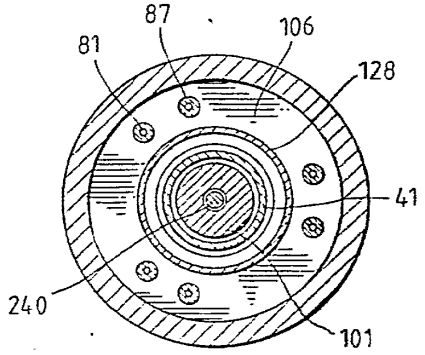


FIG.7

FIG.8

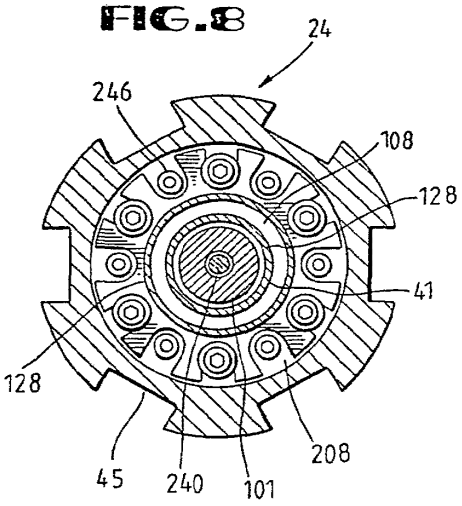
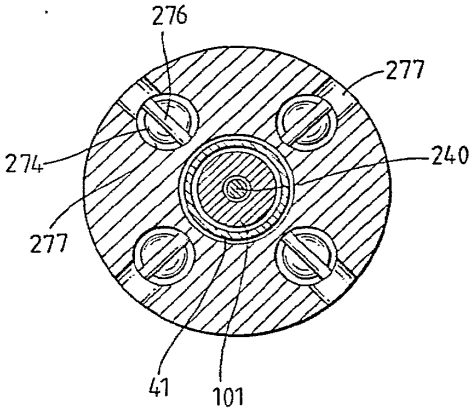


FIG.10



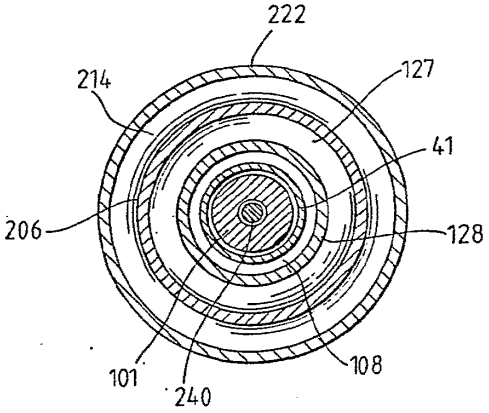


FIG.9

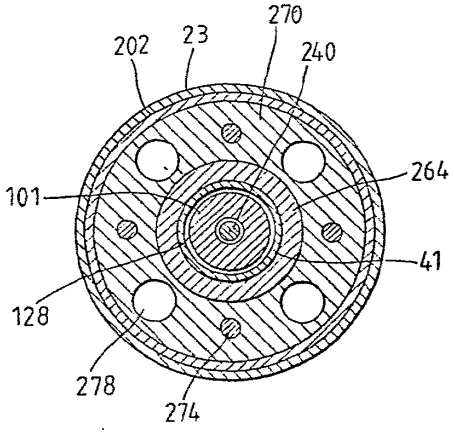


FIG.11

SELF-CONTAINED APPARATUS AND METHOD FOR DETERMINING THE STATIC AND DYNAMIC LOADING CHARACTERISTICS OF A SOIL BED

This invention relates generally to novel data gathering and sampling in connection with soil mechanics. More particularly, this invention concerns a method and apparatus for sampling and determining the dynamic loading characteristics of a soil bed, and more particularly, a method for measuring, as a function of time, the force and displacement on a soil sample as the apparatus presses into a soil bed at an uncontrolled rate resulting in a variable penetration rate. The apparatus may be used in connection with a sub-sea soil bed or a soil bed on land.

In the past, it has been common practice to extract soil samples and make laboratory measurements of data concerning the characteristics of a soil bed on the recovered samples. While some arrangements have exhibited at least a degree of utility in the gathering of data in connection with soil mechanics analysis, room for significant improvement remains.

The structural loading of soil has been a problem for many years, but these problems were not approached in an orderly manner until the advent of modern soil mechanics theory in the 1920's. The application of soil mechanics theory requires the collection of accurate data to evaluate certain soil parameters. The task of

gathering reliable data is of paramount importance in the satisfactory application of soil mechanics theory. This task becomes acutely more difficult when analyzing a soil bed that lies beneath a body of water.

As the world's oil supply dwindles and available land based drilling sites are exhausted, the need to construct offshore oil drilling platforms increases. The increased size and utilization of these offshore platforms magnifies the need for reliable data to evaluate the stability of sub-sea soil beds. Offshore platforms constructed on pilings driven into the soil bed under bodies of water proliferate in the Gulf of Mexico and along the continental shelf bordering the east and west coasts of the United States.

Data taken while sampling a soil bed helps determine the soil bed's ability to support the foundation of a structure. A foundation is only as stable as the soil bed that supports it. Accurate data collection concerning a soil bed is the first step in correctly evaluating the soil bed's ability to support a structural foundation. A stable foundation is fundamental to the stability of a structure. The need for accurate design data is paramount. A calculation based on erroneous data is a miscalculation that can produce disastrous results. A structure built upon a piling foundation, subjected to a sudden load from a wave surge or earthquake, can collapse, resulting in a loss of life and property.

The ability of a soil bed to support a structure's foundation is related to the rate a load is applied to the foundation. While a soil bed may adequately support a foundation during normal wave activity, or normal land based loading, the soil bed may not adequately support the foundation during a sudden surge in response to severe

wave action or an earthquake. An unexpected load applied suddenly to the foundation could topple the structure. Therefore, there is an important need to accurately predict the ability of a soil bed to support a structure, especially during the variable rate loading conditions experienced on land and at sea. Variable rate loading characteristics are referred to as the dynamic loading characteristics of the soil bed.

Present methods and apparatus for measuring the ability of a soil bed to support a structure are limited in several ways. First, there are no known methods or apparatus that measure the dynamic loading characteristics of a soil bed as a function of time. Moreover, present methods and apparatus utilize short displacement, cyclic, linear penetration techniques that penetrate a soil bed at a constant rate and do not measure the dynamic loading characteristics of the soil.

Known measuring systems are intolerant of a hostile sea state and require a benign sea state to obtain accurate data. Unless these methods and apparatus are used in smooth water conditions, motion compensation devices must be used to obtain accurate measurements.

Physical interface umbilicals from the surface are difficult to deploy and present a formidable, if not impossible, design challenge in deep sea applications. In addition the tremendous pressure exerted on equipment and instrumentation submerged in over five hundred fathoms of water presents a formidable design problem.

Isolating a monitoring system from extreme water pressure and from the corrosive action of the sub-sea environment is extremely difficult. These problems are exacerbated by the use of physical umbilicals.

The problems enumerated in the forgoing are not exhaustive but rather are among many which tend to impair the effectiveness of previously known soil sampling and data gathering systems. Other noteworthy problems may also exist; however, those presented above should be sufficient to demonstrate that soil sampling and data gathering systems appearing in the art have not been altogether satisfactory.

Recognizing the need for an improved soil sampling and data gathering system it is, therefore, a general object to provide a novel method and apparatus for determining the dynamic loading characteristics of a soil bed which are simple to construct and operate and which obviate the need for an umbilical between the apparatus and the surface.

Another object of the present invention is to provide a self-contained method and apparatus for determining dynamic loading characteristics of a soil bed by measuring a plurality of parameters associated therewith.

Yet another object of the present invention is to provide a method and apparatus for determining the dynamic loading characteristics of a soil bed, that can withstand the extreme pressures of deep water operations without leakage and remain isolated to neither contaminate nor be contaminated by the ocean environment.

A further object of the present invention is to provide a self-compensating method and apparatus for determining the dynamic loading characteristics of a under water soil bed that can be operated from a floating platform.

To attain these and other objectives, an apparatus for sampling a soil bed from the surface of the earth or the surface of a body of water is provided. The apparatus includes a housing adapted to attached to the bottom of a drill string. On land the housing may be attached directly to the drill string by removing the drill string from the well bore and attaching the housing to the bottom of the drill string in place of the drill bit. At sea the housing may be dropped down the drill string or lowered from a wire line within the drill string for transporting the apparatus from the surface of a body of water to a location adjacent the soil bed beneath the body of water. Additionally the apparatus includes a sub positioned in the drill string and adapted to receive the apparatus housing during sea-based operations, a sample tube extending below the housing for penetrating the soil bed, a means for attaching the housing to the bottom of the drill string, a selectively lockable means for use during sea-based operations to selectively lock the housing into the sub to enable the housing to transmit load between the drill string and the sample tube, a load detector within the housing adapted to generate a first signal corresponding to loading as a function of time on the sample tube, a movement detector within the housing adapted to generate a second signal corresponding to the upward displacement of a soil sample within the sample tube and a recorder within the housing adapted to record the first and second signals simultaneously.

The present invention is defined in the accompanying claims, both to apparatus for and a method of soil sampling, to which claims reference should now be made.

The present invention addresses the problems described above by providing a system for sampling a soil bed which is capable of operation from a floating or land-based platform. The system is further capable of pressing on a soil bed at a uncontrolled rate resulting in a variable penetration rate, and also retrieving a soil sample. The variable penetration rate is beneficial in providing insight into the dynamic loading characteristics of the soil bed.

The apparatus of the invention is self-contained. It may be attached directly to the bottom of a drill string or it may be dropped down the well bore or lowered on a wire line without removing the drilling apparatus. Consequently, samples may be obtained and retrieved from, say, a well bore without removing drilling apparatus from the bore. An instrument package may be deployed and retrieved from a well bore without removing drilling apparatus from the bore. The apparatus contains a data acquisition system that records various parameters, notably the soil penetration rate and the load required to affect penetration. Soil samples captured by the apparatus are retrievable raising the drill string or retrieving the housing by wire line, thus enabling the operator to keep the drilling apparatus in the well bore throughout the sampling.

The system of the invention is suitable for use with conventional drilling systems. The apparatus of the invention is insertable into a conventional drill string above a conventional drag bit or coring bit, i.e., a bit having a central passageway or opening. The apparatus of the invention may also be attached directly to the bottom of a drill string.

The apparatus of the invention also comprises an elongated housing, adapted at its upper end to releasably engage an overshot or the like for attachment to the lower end of a wire line. A plurality of dogs or the like are positioned near the upper end of the housing. The dogs engage recesses formed in the inner wall of the housing, and are designed to be retractable.

A sample tube, preferably cylindrical in shape, comprises or attaches to the lower end of the housing. The sample tube slides through the opening in the drill bit when the housing is locked into the drill line during sea-based operation. When the apparatus of the invention locks into position in the sub for sea-based operation, the sample tube protrudes below the bit by a selected amount, which in practice may measure about two feet or about sixty centimeters. Thus, as the sample tube presses into a soil bed, a sample of the soil enters the sample tube.

The housing portion of the apparatus generally will be an assembly of several components. A first such component, a load cell, positioned in the housing, couples to the top of the sample tube. The load cell measures the axial load imposed on the sample tube. There are many ways to measure such a load.

A second component of the housing is an instrument chamber or compartment. This component will normally contain a power pack, a data acquisition system and an electronics package. The instrument compartment may also contain an LVDT unit or other position measuring device for indicating the extent to which a core sample enters the sample tube. To activate the LVDT unit, a sample or core follower is preferably provided within the sample chamber. The core follower includes a piston immediately above a sample in the sample tube and a piston rod attached to the piston. As a soil sample enters the sample tube, the piston travels upward. The LVDT core rod attaches to the piston to provide a measurement of the sample length.

From these features of the invention, it becomes apparent that use of the invention provides a continuous record of the load acting to penetrate and withdraw a soil bed, as well as the extent of penetration. The invention also provides a soil sample which is retrievable from the surface of a body of water or from the surface of the earth.

An especially attractive feature of the invention is its ability to operate without motion compensation. Thus, movement of a floating vessel or platform from which the invention operates may vary the loading on the sample tube as well as its rate of penetration without degradation of the measurement data's accuracy. However, these are the same type of dynamic factors which affect the legs of platforms, pilings or other structural members which penetrate a soil bed. Hence, the dynamic data provided by the present invention provides a very useful insight into the dynamic performance to be expected of such structural members in a soil bed from which the data is obtained.

In accordance with the invention, the load data and the penetration data for a given soil sample are recorded with time as the sample tube presses into the soil. The resulting records are especially valuable in reflecting the uniformity of the soil.

The invention has particular application not only in offshore operations, but is also of great interest in land based operations. In addition to oil and gas drilling structures, the invention is useful in other offshore and land based structures such as, for example, bridges, towers, tall buildings, and the like. The dynamic characteristics are useful in the evaluation of soil properties for earthquake analysis.

In one aspect of the present invention, a method is provided for determining the dynamic loading characteristics of a soil bed by measuring the forces exerted on a self-contained, environmentally isolated data measurement and sampling apparatus. A sample tube presses into the soil bed at an uncontrolled rate resulting in a variable penetration rate. The data acquisition system measures and records the force, as a function of time, exerted on the sample tube during penetration and withdrawal. The data acquisition system measures and records the depth of penetration as a function of time. These measurements are used to determine the dynamic loading characteristics of the soil bed. The method includes a step whereby the sample tube captures a soil sample for laboratory analysis at the surface.

Soil parameters of primary interest are pile design parameters with an emphasis on open ended steel pipe piles which are used offshore. If a steel pipe pile and a steel sample tube are compared, they are of very similar proportions. It is therefore to be expected that the

parameters measured while pushing a sampling tube into a soil bed may be applied to driving a pile into the soil. The value of these measurements is accordingly apparent. With appropriate interpretation and modification, the measurements taken during sampling may be applied advantageously to pile design.

Additional objects, features and advantages of the present invention will become apparent with reference to the following detailed description of a preferred embodiment thereof in connection with the accompanying drawings, wherein like reference numerals have been applied to like elements, in which drawings :

Figure 1A is a schematic or conceptual drawing that shows a boring drilled to the desired depth in a soil bed using an open ended drag bit.

Figure 1B is a schematic or conceptual drawing of one embodiment of the apparatus of the invention as it is lowered into the drill string and latched into place. The sampling tube extends beneath the open drill bit at the end of the drill string.

Figure 1C is a schematic or conceptual drawing that shows a drill string pushing the sampling apparatus of the invention into the sub-sea soil bed.

Figure 1D is a schematic or conceptual drawing that shows the sampling apparatus of the invention after it is fully inserted into the soil bed to a depth d2.

Figure 1E is a schematic or conceptual drawing that shows the drill string as it withdraws the sampling apparatus to remove it from the soil bed.

Figure 1F is a schematic or conceptual drawing that shows the retrieval system as it attaches to the top end of the apparatus, unlatches the apparatus from the drill string and raises the apparatus to the surface.

Figure 2 is a graph that shows possible force and displacement curves, plotted as a function of time. Time

t1 corresponds to depth d1 in Figure 1C. Time t2 corresponds to depth d2 in figure 1D.

Figure 3A is a partial longitudinal section view that shows the top section of one embodiment of the apparatus of the invention. The apparatus is divided into four sections in Figures 3A-3D.

Figure 3B is a partial longitudinal section view that shows the second section of the apparatus.

Figure 3C is a partial longitudinal section view that shows the third section of the apparatus.

Figure 3D is a partial longitudinal section view that shows the fourth section of the apparatus.

Figure 4 is a view taken along section lines 4-4 of Figure 3A.

Figure 5 is an exploded view of a retaining clamp to hold the LVDT in place and to prevent the LVDT from being pushed into the instrument compartment by extreme water pressures at great depths under water.

Figure 6 is a view taken along section lines 6-6 of Figure 3B.

Figure 7 is a view taken along section lines 7-7 of Figure 3C.

Figure 8 is a view taken along section lines 8-8 of Figure 3C.

Figure 9 is a view taken along section lines 9-9 of Figure 3C and shows the load cell web. All the load is

transmitted through the load cell web. The outer sleeve of the load cell and the inner sleeve of the load cell are shown along with the piston sleeve, the LVDT and the LVDT core rod.

Figure 10 is a view taken along section lines 10-10 of Figure 3D and shows a fluid release orifice positioned at the top of each ball valve channel. The piston sleeve, the LVDT and the LVDT core rod are shown concentrically located in the apparatus housing.

Figure 11 is a view taken along section lines 11-11 of Figure 3D and shows the piston sleeve bearing secured to the piston sleeve bearing retainer.

While the invention is susceptible to various modifications and alternative forms, specific embodiments thereof have been shown by way of example in the drawings and are herein described in detail. It should be understood, however, that it is not intended to limit the invention to the particular forms disclosed. On the contrary, the intention is to cover all modifications, equivalents, and alternatives falling within the spirit and scope of the invention as defined by the appended claims.

This detailed discussion of the apparatus of the invention is not intended to be exhaustive. It is readily envisioned that the apparatus may embody various types and styles of each element without departing from the spirit and scope of the invention.

Figures 1A-1F and Figures 3A-3D show an apparatus for sampling from the surface of land or a body of water a soil bed at the bottom of a bore hole in the presence of a drill string constructed according to a preferred

embodiment of the invention. The apparatus may be seen to comprise seven main subassemblies; namely a housing assembly 14 adapted to be dropped down a drill string or lowered by a wire line within the drill string and utilized for transporting the apparatus of the invention from the surface 31 of land or of a body of water 21 to a location adjacent the soil bed, a drill string latching sub assembly 17 positioned in the drill string adapted to receive the housing assembly, a sample tube assembly 23 extending below the bottom of the drill string 30 and beyond the drill bit 42 for penetrating and sampling the soil bed, selectively lockable means 20 to lock the housing into the drill string latching sub assembly 17 to enable the drill string 30 to apply an axial load to the housing assembly 14 through the load detector assembly 9 to the sample tube assembly 23, a load detector assembly 9 within the housing assembly 14 adapted to generate a first signal corresponding to loading as a function of time on the sample tube assembly 23, a movement detector assembly 16 within the housing assembly 14 adapted to generate a second signal corresponding to the upward displacement of a soil sample within the sample tube and a recorder assembly 18 within the housing assembly 14 adapted to record said first and second signals simultaneously.

THE HOUSING ASSEMBLY

The housing assembly 14 of the present invention is utilized to contain the load detector assembly 9, the movement detector assembly 16, the sample tube 23, the recorder assembly 18 and the selectively lockable means 20 down the well bore 13 and through the drill string 30 without removing the drill string 30 from the well bore 13. The operator drops the housing assembly 14 down the drill string 30 or lowers the housing assembly 14 down through the drill string 30 using a wire line 28 attached to an over shot assembly 29. The over shot assembly

attaches to overshot adaptor 22 at the top of the housing assembly 14. The operator lowers the apparatus of the invention through the drill string 30 to a location adjacent the bottom 12 of the well bore 13 drilled into a soil bed 35.

The drill string 30 may contain a latching sub assembly 17. The latch-in assembly 34 contains the selectively lockable means 20. The selectively lockable means locks into the drill string latching sub assembly 17 locking the housing assembly 14 into the drill string 30. The latch-in assembly 34 is secured to the adaptor for the latch-in assembly 62 by threads 60 formed on the latch-in assembly adaptor tapered member 26. The threads 60 are formed on tapered member 26 at the top of the latch-in assembly adaptor body 61.

The landing ring 24 attaches to the housing assembly 14. The drill string 30 contains drill string landing sub assembly 19 with an drill string landing ring 25 near the bottom of the drill string 30. The landing ring 24 engages the drill string landing ring 25 positioning the housing assembly 14 in the drill string 30 as the housing assembly 14 is lowered by a wire line 28 or dropped and allowed to free fall into place in the drill string 30. The selectively lockable means 20 engages the drill string latching sub assembly 17 when the landing ring 24 positionally engages the drill string landing ring 25. The landing ring 24 is fluted to allow fluid to pass through the flutes 45.

In land-based operations the operator may drill a well bore 13 using a drill bit 42 and then remove the drill string 30 from the well bore 13. The operator may remove the drill bit 42 and replace it with the housing 14. The housing 14 attaches to the bottom of the drill

string 30. The threads 60 on the tapered member 26 engage the threads at the bottom of the drill string 30. The operator may lower the drill string 30 with the attached housing 14 down into the well bore to a position adjacent the soil bed. The drill string then forces the sample tube 23 into the soil bed. The operator removes the drill string 30 to retrieve the housing 14 and the soil sample 50.

The housing assembly 14 includes a plurality of sleeves and annular transition members that form the exterior sheath of the housing assembly. The sleeves and transition members slide over the cylindrical members of the housing assembly. A plurality of cap screws secure the housing assembly sleeves and transition members to the cylindrical members.

The adaptor for the latch-in assembly 62 slides into housing exterior sleeve member 66. One or more cap screws 64 secure housing exterior sleeve member 66 to latch-in assembly adaptor body 61. The aperture 63 enables mechanical engagement and rotation clockwise and counterclockwise of cap screws 64. The cap screw threads 65 engage latch-in assembly adaptor body 61.

The instrument compartment plug 68 slides into the housing exterior sleeve member 66. One or more cap screws 70 secure housing exterior sleeve member 66 to instrument compartment plug 68. The aperture 72 enables mechanical engagement and rotation clockwise and counterclockwise of the cap screws 70. The cap screw threads 73 engage the instrument compartment plug 68.

An o-ring seal forms a water tight seal between the instrument compartment plug 68 and the exterior sleeve member. The o-ring seal includes an o-ring 74, an o-ring

groove 76 and an o-ring backing 75. The o-ring 74 fits within the o-ring backing 75. The o-ring backing 75 fits within the o-ring groove 76.

The housing exterior sleeve member 66 attaches to the housing member 106 by engaging threads 302. The aperture 118 enables mechanical engagement for rotation of the housing exterior sleeve member 66 clockwise and counterclockwise. The aperture 54 enables mechanical engagement for rotation of housing member 106 clockwise and counterclockwise.

An o-ring seal forms a water tight seal between the housing exterior sleeve member 66 and the housing member 106. The o-ring seal includes an o-ring 104, an o-ring groove 105 and an o-ring backing 103. The o-ring 104 fits within the o-ring backing 103. The o-ring backing 103 fits within the o-ring groove 105.

The upper housing member 106 slides into the lower housing member 126. The cap screws 124 secure the housing member 126 to the housing member 106. The apertures 130 enable mechanical engagement and rotation clockwise and counterclockwise of the cap screws 124. The cap screw threads 129 engage the housing member 106.

An o-ring seal forms a water tight seal between the housing member 106 and the housing member 126. The o-ring seal includes an o-ring 122, an o-ring groove 56 and an o-ring backing 123. The o-ring 122 fits within the o-ring backing 123. The o-ring backing 123 fits within the o-ring groove 56.

The housing member 126 attaches to the sleeve member 200 by engaging the threads 212. The aperture 109 enables mechanical engagement for rotation of the housing member

126 clockwise and counterclockwise. The landing ring 24 attaches to the sleeve member 200. The sleeve member 200 attaches to the upper portion of the load cell 208 by engaging the threads 125. The exterior load cell sleeve 222 slides over the load cell 208.

The sample head 202 attaches to the lower portion of the load cell 208 by the engaging threads 236. The aperture 203 enables mechanical engagement for clockwise and counterclockwise rotation of the sample head 202.

The sample head 202 slides into the sample tube 23. The cap screws 250 secure the sample tube 23 to the sample head 202. The aperture 251 enable mechanical engagement and rotation clockwise and counterclockwise of the cap screw 250. The cap screw threads 252 engage the sample head 202.

An o-ring seal forms a water tight seal between the sample head 202 and the sample tube 23. The o-ring seal includes an o-ring 242, an o-ring groove 244 and an o-ring backing 243. The o-ring 242 fits within the o-ring backing 243. The o-ring backing 243 fits within the o-ring groove 244.

The housing orifice 71 is used to facilitate machining of the latch-in assembly adaptor body 61.

THE DRILL STRING LANDING SUB ASSEMBLY

The drill string landing sub assembly 19 is configured to engage the landing ring 24 as the housing assembly 14 is dropped or lowered on a wire line 28 through the drill string 30. The drill string landing sub assembly 19 contains a drill string landing ring 25 to engage the landing ring 24 and halt the downward motion of

the housing assembly 14 with respect to the drill string 30.

THE SAMPLE TUBE ASSEMBLY

The sample tube 23 attaches to the sample head 202 as a member of the housing assembly 14. The housing assembly 14 latches into the drill string 30 by means of latch-in assembly 34. The sample tube 23 hangs down through the bottom of the drill bit 42. The sample head 202 attaches to the load cell 208. The axial load placed on the sample tube 23 is transmitted through the sample head 202 to the load cell 208.

There are numerous other means for taking a soil sample that may be used in the present invention and the apparatus or method of the invention is not limited to the use of a cylindrical sample tube. The invention contemplates the use of any shape sampler such as a square, rectangle, triangle or any other suitable shape. The invention also contemplates the use of any means or method of extracting the soil sample, such as coring, trepanning or any other suitable method or apparatus.

THE SELECTIVELY LOCKABLE MEANS ASSEMBLY

The selectively lockable means assembly is used to lock the housing assembly 14 into the drill string 30. In a preferred embodiment the selectively lockable means 20 is a set of latching dogs as shown in Figure 1B that disengage the recess 15 in the drill string latching sub assembly 17 when the overshot 29 and wire line 28 engage the overshot adaptor 22 and pull upwards on the apparatus housing assembly 14. The upward motion on overshot adaptor 22 moves sliding member 53 upward in groove 52 causing the latching dogs to pivot back into the latch-in assembly, disengaging the latching dogs. Upward tension on sliding member 53 causes the latching dogs to pivot into the

recesses of the latch-in assembly 34. The latching dogs are weighted so that they are normally pivoted outwardly to protrude from the exterior of the latch-in assembly 34. The selectively lockable means 20 automatically engages the drill string latching sub assembly 17 when the housing assembly 14 is lowered or dropped into place in the drill string.

THE LOAD DETECTOR ASSEMBLY

The load detector assembly is used to measure the force exerted on the sample tube 23. The load cell 208 attaches to the sample head 202 and the sample head attaches to the sample tube 23 as described in the description of the housing assembly. Retaining pin 234 passes though the exterior load cell sleeve 222, the load cell 208 and the interior load cell sleeve 228. The load exerted on the sample tube 23 is transmitted to the load cell 208. The strain gauges 210 are attached to the load cell web 206. The load cell web 206 is positioned in the load cell recess 214. The load cell wiring 92 runs from the strain gauges 210 through the load cell wiring connector 91, the feed through apertures 85, the feed through connector 84, the feed through apertures 246, the feed through apertures 87, the feed through connectors 81 and the load cell wiring passage 93 to connect the load cell to the instrument compartment interface connector 90. The protector sleeve 128 separates the load cell wiring from the piston sleeve 41.

The o-ring seals keep water out of the load detector assembly. The o-ring seals include an upper interior o-ring seal, an upper exterior o-ring seal, a lower interior o-ring seal and a lower exterior o-ring seal. The upper interior o-ring seal includes o-ring 220, an o-ring groove 221 and an o-ring backing 223. The lower interior o-ring seal includes an o-ring 218, an o-ring groove 217 and an

o-ring backing 215. The upper exterior o-ring seal includes an o-ring 204, an o-ring groove 205 and an o-ring backing 209 and o-ring 216. The lower exterior o-ring seal includes an o-ring 216, an o-ring groove 213 and an o-ring backing 219.

The upper and lower exterior o-ring seals fit between the load cell 208 and the exterior load cell sleeve 222. The upper and lower interior o-ring seals fit between the load cell 208 and the interior load cell sleeve 228. The exterior load cell sleeve 222 does not abut the sleeve member 200 leaving a space 224 between the exterior load cell sleeve 222 and the sleeve member 200. The exterior load cell sleeve 222 does not abut the sample head 202 leaving a space 226 between the sleeve 222 and the sample head 202. An annular space 108 exists between the piston sleeve 41 and the LVDT 101. An annular space 127 exists between the piston sleeve 41 and the protection sleeve 128.

There are numerous other means for measuring load that may be used in the invention and the apparatus of the invention is not limited to the use of a load cell. The apparatus of the invention contemplates the use of any suitable self-contained means for measuring load.

THE MOVEMENT DETECTOR ASSEMBLY

The movement detector assembly is utilized to measure the amount of soil sample 50 forced into the sample tube 23. The sample-follower piston 40 travels along the housing longitudinal axis and inside the sample tube 23. A piston sleeve 41 is attached to the sample-follower piston 40. The displacement of the piston head is measured by a means for measuring movement. In a preferred embodiment this means can be a linear displacement transformer LVDT 101 as shown in Figure 3D.

There are numerous other means for measuring displacement that could be used in a preferred embodiment and the apparatus of the invention is not limited to the use of a LVDT. The apparatus of the invention contemplates the use of any self contained means for measuring displacement.

The sample follower piston 40 includes a piston face 254 and a piston hub 256. The piston sleeve or hollow piston sleeve 41 slides into the piston hub. The cap screw 258 passes through the piston sleeve 41 and into the piston hub 256 and secures the piston sleeve 41 within the piston hub 256. The LVDT core rod 240 slides into the piston hub 256 and is secured into the piston hub by cap screw 258.

As shown in Figure 5, the LVDT 101 passes through the LVDT retaining bracket orifice 230 into the LVDT retaining bracket 112. The LVDT retaining bracket 112 engages the top portion 96 of the LVDT and clamps the LVDT 101 in place. The LVDT retaining bracket 112 slides over the LVDT 101 and abuts the top portion 96 of the LVDT. The cap screw 116 passes through the aperture 120 and engages the LVDT retaining bracket 112 to close the gap 55 and reduce the diameter of the orifice 230 and tighten the LVDT retaining bracket 112 around LVDT 101. LVDT retaining bracket 112 fits into the LVDT retaining groove 97 at the top portion 96 of the LVDT. The threads 117 engage the LVDT retaining bracket 112. The orifice 119 in the cap screw head 118 enables mechanical engagement and rotation clockwise and counterclockwise of cap screw 116.

The cap screw 114 passes through the aperture 121 in the LVDT retaining bracket 112 and secures the retaining bracket to housing member 106. The cap screw threads 107 engage the housing member 106. The aperture 113 enables

mechanical engagement and rotation clockwise and counterclockwise of the cap screw 77. The LVDT wiring 92 passes through the wiring passage 110 and connects the LVDT to the instrument compartment interface connector 90.

The piston sleeve 41 slides along the longitudinal axis of the housing on piston bushings 262 and 264. The upper piston bushing 262 also serves as stop for engaging the piston stop 43. The piston stop 43 keeps the piston from falling out of the end of the housing assembly 14. The piston bushing 262 is held in place by the bushing retainer 266. The bushing retainer 266 is secured to the sample head 202 by the cap screw 268. The cap screw threads 269 engage the sample head 202 to secure the bushing retainer 266. The piston bushing 264 is held in place by the bushing retainer 270. The bushing retainer 270 is secured to the sample head 202 by cap screw 272. The cap screw threads 271 engage the sample head 202 to secure the bushing retainer 270. The piston stop 43 engages the bushing 262.

The check valve 278 allows fluid or other matter in sample tube 23 to escape through the escape valve orifice 277 as the soil sample fills the sample tube 23 and displaces any water or other matter within the sample tube 23. The reduced diameter portion of the check valve 278 forms a seat 275 for the ball 274. The check valve ball 274 moves up and away from the valve seat 275 while fluid escapes during soil capture. The retaining pin 276 prevents the ball 274 from falling out of the valve. When the housing withdraws from the soil, the ball 274 returns to a resting position and rests on the valve seat 275 and seals the escape valve orifice 277 to form a suction on and retain the soil sample 50 in the sample tube 23.

THE RECORDER ASSEMBLY

The recorder assembly is utilized to record the data measured from the load detector and movement detector and any other detector simultaneously. The data recorder assembly includes the battery pack 38, the data acquisition system 39 and the electronics package 37. The wiring 300 connects the battery pack 38 to the data acquisition system 39 and the wiring 301 connects the battery pack to the electronic package. The wiring 301 connects the electronics package 37 to the data acquisition system 39. The wiring 303 connects the instrument compartment interface connector 90 to the data acquisition system 39 and the electronics package 39.

The LVDT wiring 99 connects the LVDT to the instrument compartment interface connector 90 and thus to the recording assembly. The load cell wiring 92 connects the load cell to the instrument compartment interface connector 90 and thus to the recording assembly. The battery pack 38, the data acquisition system 39 and the electronics package are contained in the instrument compartment 36.

The external data ports 94 are mounted on the housing recess 102 to provide a means for retrieving data from the data recorder assembly. The housing recess 102 keeps the external data ports 94 recessed and protected during operations. The rubber nipple 95 slides over and protects the external data ports 94. The external data port wiring 100 connects the external data ports 94 to the data acquisition system 39 for retrieval of data.

The apparatus of the invention is not limited to the use of the specific data acquisition system described here. The apparatus of the invention contemplates the use of any self-contained means for recording data. Thus, the

invention contemplates the use of optical disk storage, magnetic disk storage, and the like. The invention also contemplates the use of self-contained data acquisition systems that do not store data but transmit data to the surface without the use of a physical data cable umbilical from the surface to the apparatus of the invention.

OPERATION OF THE INVENTION

A. APPARATUS DEPLOYMENT AND RETRIEVAL OPERATIONS

In operation, the operator drills an well bore 13 into a soil bed 35 and raises the drill bit 42 approximately 2-5 feet off the soil bed 12 at the bottom of the well bore 13. The operator either drops the housing assembly 14 down through the well bore 13 or he may lower the housing assembly 14 on a wire line 28 through the well bore without removing the drilling apparatus 30 from the well bore 13. To lower the housing assembly 14 on a wire line 28, the operator attaches a wire line 28 and overshot 29 to the overshot adaptor located on the top of the housing assembly 14 or tool.

The selectively lockable means 20, located in the latch-in assembly 34, engages the latch recess 15 in the drill string sub assembly 17 located above the drill bit 42 at the bottom of the drill pipe.

The landing ring 24 formed on the apparatus housing assembly 14 abuts the drill string landing ring 25 at the bottom of the drill string 30 during deployment to limit the downward progress of the housing assembly 14. The fluted exterior of the landing ring 24 allows fluid to pass through the flutes 45 as the housing assembly 14 moves through the drill string 30.

The operator may retrieve the housing assembly 14 by lowering an overshot 29 on the end of a wire line 28 which

engages the top of the housing assembly 14. As the wire line 28 pulls up on the latch-in assembly 34, the latching dogs rotate back into the latch-in assembly 34 and disengage the recess 15 in drill string latching sub assembly 17. The wire line 28 pulls the housing assembly 14 to the surface where the user recovers the data stored by the data acquisition system 39.

In land-based operations the operator may drill a well bore 13 using a drill bit 42 and then remove the drill string 30 from the well bore 13. The operator may remove the drill bit 42 and replace it with the housing 14. The housing 14 attaches to the bottom of the drill string 30. The threads 60 on the tapered member 26 engage the bottom of the drill string 30. The operator lowers the drill string 30 with the attached housing 14 down into the well bore to a position adjacent the soil bed. The drill string 30 then forces the sample tube 23 into the soil bed. The operator removes the drill string 30 to retrieve the housing 14 and the soil sample 50.

B. LOAD AND DISPLACEMENT MEASUREMENT OPERATIONS

As the drill string is lowered in the well bore, the LVDT 101 measures the displacement of the sample-follower piston 40 within the sample tube 23. The sample-follower piston 40 follows the progress of the soil sample 50 within the sample tube 23, as the drill string forces the sample tube into the soil bed. The load cell 208 measures the force exerted on the sample tube 23. The data acquisition system 39 concurrently reads and stores the force and displacement measurements as a function of time.

C. DATA CAPTURE OPERATIONS

The sample tube 23 normally penetrates the soil bed 12 at the bottom of the well bore 13 at a variable rate, enabling the determination of dynamic loading

characteristics. The rate is uncontrolled in the sense that it is subject to such factors as inconsistencies in the soil bed and load fluctuations in the drill string. The tool can operate in a hostile sea state without data degradation because the data measurements are taken as a function of time. The operator retrieves the data stored by the data acquisition system 39 through the external data ports 94 after the tools returns to the surface.

The instrument compartment 36 contains the data acquisition system 39, the battery pack 38 and the electronics package 37. The instrument compartment interface connector connects the data acquisition system 39, the battery pack 38 and the electronics package 37 to the load cell 208, and LVDT 101 and external data ports 94. The instrument compartment interface connector 90 accommodates wire connections from the exterior data ports 94, the load cell 208 and from the LVDT 101.

The soil sampling and data gathering apparatus tool is totally self-contained. The tool provides its own power supply, measuring instruments and data acquisition system. A battery pack 38 provides electric power to the load cell, the LVDT, the data acquisition system and the electronics package. A plurality of o-ring seals isolate the apparatus so that it is not contaminated by the exterior environment nor does it contaminate the exterior environment.

The electronics package 37 provides an electronic interface between the data acquisition system 39 and the load cell 208, LVDT 101 and external data ports 94. The data acquisition system 39 may be comprised of an industry standard module such as the *Tattletale* Model V, available from ONSET Computer Corp., P.O Box 1030, 199 Main Street, N. Falmouth, MA 02556.

The data acquisition system typically includes a central processing unit, a universal asynchronous receiver/transmitter, an analog to digital converter, static RAM and EPROM. The data acquisition system takes analog signals from the load cell and LVDT and converts them to digital signals. The data acquisition system samples the analog signals from the load cell and LVDT at regular intervals, as for example every 10 milliseconds, converts these analog measurements into digital signals and stores the digital signals. The resulting data measurements represent a force curve 32 and displacement curve 33 as a function of time during the sampling session.

The invention is not limited to any particular conventional data acquisition system. The invention contemplates any suitable data sampling and storage device, such as optical disc or any other means of data storage. There are numerous uses for the recovered measurement data. It is contemplated that additional uses and interpretations will develop as the users of the invention gain experience with the apparatus and method and the data derived from its use.

D. SOIL CAPTURE OPERATION

The sampling tube 23 typically hangs down about 2 feet beyond the bottom of the drill bit 42. The operator allows the drill string 30 to descend at an uncontrolled rate which presses the sample tube 23 into the soil bed at a variable rate. The pressure from the drill string forces a soil sample 50 into the sample tube 23 as the sample tube 23 penetrates the soil bed 12 at the bottom of the well bore 13. The sample-follower piston 40 tracks the progress of the soil sample 50 as it enters the sampling tube 23. The check valve 278 allows fluid to escape from the sampling tube 23 as the soil sample 50 displace fluid

in the sample tube 23. When the sample tube 23 withdraws from the soil bed 12, the check valve ball 274 seats and seals to provide suction that holds the soil sample 50 in the sample tube 23.

The apparatus captures a soil sample 50 in the sampling tube 23, and gathers data on the soil bed 12, in situ, concurrently. The uncontrolled descent of the drill string 30 forces the sampling tube 23 into the soil at a variable penetration rate, enabling the user to determine the dynamic and static loading characteristics of the soil bed. The time measurements also facilitate data corrections for variable loading.

E. LOAD MEASUREMENT OPERATIONS

The load cell 208 measures the force exerted on the sample tube 23. The force on the sample tube 23 is transmitted from the sample tube 23 through the sample head 202 to the load cell 208. The top of the load cell 208 screws into the sleeve member 200 and the bottom of the load cell 208 screws into sample head 202.

The load cell wiring 92 from the load cell 208 connects to the load cell wiring connector 91 and passes upwardly through the load cell wiring passage 93 and connects to the instrument compartment interface connector 90. The data acquisition system 39 records the load measured by the load cell as a function of time.

A plurality of strain gauges 210 attach to the load cell web 206 to determine the load as a average of the measurements taken at the strain gauges. The load cell wiring 92 runs from the strain gauges 210 up through the load cell wiring passage 93. The load cell wiring passage 93 is sealed to keep water and other contaminants. The load cell web 206 is positioned between the interior load

cell sleeve 228 and the exterior load cell sleeve 222. The load cell is sealed by a series of upper and lower load cell o-rings 204, 220, 216 and 218 placed between the load cell and the interior and exterior load cell sleeves. The exterior load cell sleeve 222 protects the load cell from the environment. The outer load cell sleeve is separated from the sleeve member 200 by a space 224 and a space 226 so that the axial load passes through the load cell instead of sleeve member 200.

F. DISPLACEMENT MEASUREMENT OPERATIONS

The sample-follower piston 40 hangs down inside the sample tube 23. The sample-follower piston 40 follows the soil sample 50 into the sampling tube 23 as the drill string 30 pushes the sampling tube 23 into the soil bed 12. The LVDT core rod 240 attaches to the soil follower piston hub 256 by means of cap screw 259. The LVDT 101 measures the progress of the soil sample 50, as it moves into the sample tube 23 displacing the sample-follower piston 40 and attached LVDT core rod 240. The LVDT core rod 240 moves within the LVDT 101 and generates an electrical signal proportional to the displacement of the LVDT core rod 240 and sample-follower piston 40. The cap screw 258 allows for adjustment of the sample-follower piston 40 position relative to the LVDT core rod 240 to fix the piston face 254 on the LVDT core rod 240 at the calibrated null position of the LVDT 101.

The LVDT 101 remains environmentally isolated and water tight even at extreme water pressure through the use of the LVDT o-ring. LVDT retaining screw 114 secures the LVDT retaining bracket 112 to housing member 106.

The piston sleeve 41 slides on replaceable bushings 262 and 264. The bushings keep the piston sleeve aligned along the longitudinal axis of the apparatus without

rubbing against the LVDT. The piston sleeve annular stop 43 abuts the upper piston sleeve bushing 262 and halts the downward motion of the sample follower piston 40.

SUMMARY OF ADVANTAGES

It will be appreciated that the method and apparatus for determining the dynamic characteristics of a soil bed by penetrating a soil bed at a variable penetration rate and measuring the force and displacement of the sampling device as a function of time of the present invention, provide certain significant advantages.

The present invention is self-contained and environmentally sealed. The apparatus is capable of operating on land or at great depths under the sea. The apparatus is simple and easy to build, with fewer parts than known systems. The apparatus reduces or eliminates the need for a physical data and control umbilical to the surface. The method can be performed on land or in a benign or hostile sea state without the need for motion compensation. The method may also be performed more quickly than known methods. The concurrent acquisition of a core or soil sample as well as load data and penetration data provides a valuable insight into the characteristics of a soil bed and its pile carrying capacity.

CLAIMS:

1. Apparatus for sampling a soil bed at the bottom of a bore hole in the presence of drill string which comprises:

a housing adapted to be positioned in a drill string for transporting said sampling apparatus from the surface to a location adjacent the soil bed;

a receiving assembly positioned in the drill string adapted to receive the housing;

a sample tube extending below the housing for penetrating the soil bed;

selectively lockable means to selectively lock the housing into the receiving assembly and mechanically transmit compression and tension forces between the drill string and the sample tube sufficient to enable the sample tube to penetrate the soil bed and displace a soil sample upwardly into the sample tube;

a load detector within the housing adapted to generate a first signal corresponding to compression and tension forces as a function of time on the sample tube;

a movement detector within the housing adapted to generate a second signal corresponding to the upward

displacement as a function of time of a soil sample within the sample tube; and

a recorder within the housing adapted to record the first and second signals concurrently.

2. The apparatus of claim 1 in which the sampler is a right circular cylinder capable of retaining a sample of the soil bed which enters the sampler during such penetration.

3. The apparatus of claim 1 or 2 in which the load detector comprises a load cell.

4. The apparatus of claim 3 in which the load detector is located between the sample tube and the drill string.

5. The apparatus of any of claims 1 to 4, in which said movement detector is a linear displacement transducer.

6. The apparatus of claim 5 in which said linear displacement transducer comprises a piston within a right

circular cylinder that follows the soil sample up into the cylinder during penetration.

7. The apparatus of any of claims 1 to 6, which is sealed so that the force and movement signals can be taken at depth without environmental contamination of said housing.

8. A method of sampling a soil bed using a drill string, which comprises the steps of:

releasably engaging a sample tube within the drill string such that a length of the tube extends through and below the bottom of the drill string;

lowering the drill string to impose a compression force on the tube sufficient to thereby penetrate the soil bed and displace a soil sample into the tube;

detecting the compression forces imposed on the tube as a function of time during such penetration;

detecting the displacement of the soil sample into the tube with time during such penetration;

recording down the well during such penetration the compression forces and displacement so detected; and

retrieving through the drill string the sample tube together with the records recorded down the well.

9. The method of claim 8 which further comprises the steps of:

raising the drill string to withdraw the tube from the soil bed;

detecting the tension forces on the tube as a function of time during such withdrawal;

detecting the displacement, if any, of the soil sample within the tube with time during such withdrawal; and

recording down the well during such withdrawal the tension forces and displacement so detected.

10. The method of claim 9 wherein the compression and tension forces are detected using strain gauges.

11. The method of claim 9 or 10 wherein the displacement is measured using an LVDT.

12. The method of claim 9, 10 or 11 wherein the displacement and compression and tension forces are detected concurrently.

13. The method of any of claims 9 to 12 which further comprises displaying the displacement and compression and tension force measurements.

14. Apparatus for sampling a soil bed at the bottom of a bore hole in the presence of a drill string having a central passageway which comprises:

a housing adapted to be attached to the bottom of the drill string and lowered to a location adjacent the soil bed;

a sample tube extending below the housing capable of penetrating the soil bed;

an attachment means to connect said housing to the bottom of the drill string to enable compression and tension forces to be transmitted between the drill string

and said sample tube sufficient to force said sample tube to penetrate the soil bed and displace a soil sample upwardly into the sample tube;

a load detector within the housing adapted to generate a first signal corresponding to the compression and tension forces on the sample tube as a function of time;

a movement detector within the housing adapted to generate a second signal corresponding to the upward displacement of a soil sample within the sample tube as a function of time; and

a recorder within the housing adapted to record the first and second signals concurrently.

15. The apparatus of claim 14 in which the sampler is a right circular cylinder capable of retaining a sample of the soil bed which enters the sampler during such penetration.

16. The apparatus of claim 14 in which the load detector comprises a load cell.

17. The apparatus of any of claims 14 to 16 in which the load detector is capable of measuring both compression and tension forces.

18. The apparatus of any of claims 14 to 17 in which said movement detector is a linear displacement transducer.

19. The apparatus of claim 18 in which said linear displacement transducer comprises a piston within a right circular cylinder that follows the soil sample up into the cylinder during penetration.

20. Apparatus for sampling a soil bed at the bottom of a bore hole which comprises:

a housing adapted to be dropped down a drill string or lowered from a wire line within the drill string, said housing configured to be landed within the drill string;

a sample tube extending below the housing capable of passing through the central passageway of a coring bit or a drag bit and penetrating into a soil bed;

a reversible locking member carried by the housing operable to lock the housing within the drill string in a manner to enable the axial load on the drill string to be transmitted through the housing to the sample tube;

a load detector within the housing adapted to generate a first signal corresponding to such axial load as a function of time;

a movement detector within the housing adapted to generate a second signal corresponding to the upward displacement as a function of time of a soil sample within the sample tube; and

a recorder within the housing adapted to record said first and second signals concurrently.

21. The apparatus of claim 20 in which said sample tube is a right circular cylinder capable of retaining a sample of the soil bed which enters the sampler during such penetration.

22. The apparatus of claim 20 or 21 in which the load detector comprises a load cell.

23. The apparatus of any of claims 20 to 22 in which said movement detector is a linear displacement transducer.

24. The apparatus of any of claims 20 to 23 which further comprises a battery pack within the housing capable of powering the detectors and the recorders.

25. The apparatus of claim 21 wherein the movement detector includes a piston within the sample tube which is positionally responsive to a sample within the sample tube.

26. Apparatus for sampling a soil bed substantially as specifically described herein with reference to the accompanying drawings.

27. A method of sampling a soil bed substantially as specifically described herein with reference to the accompanying drawings.

Published 1991 at The Patent Office. Concept House. Cardiff Road. Newport. Gwent NP9 1RH. Further copies may be obtained from Sales Branch. Unit 6. Nine Mile Point. Cwmfelinfach. Cross Keys. Newport. NP1 7HZ. Printed by Multiplex techniques ltd. St Mary Cray. Kent.

Electronic Patent Application Fee Transmittal

Application Number:	14692484
Filing Date:	21-Apr-2015
Title of Invention:	CORE BARREL HEAD ASSEMBLY WITH AN INTEGRATED SAMPLE ORIENTATION TOOL AND SYSTEM FOR USING SAME
First Named Inventor/Applicant Name:	CHRISTOPHER L. DRENTH
Filer:	Joseph P. Anderson
Attorney Docket Number:	36362.0150U2-

Filed as Large Entity

Filing Fees for Utility under 35 USC 111(a)

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
Pages:				
Claims:				
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				
Extension-of-Time:				

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Miscellaneous:				
Submission- Information Disclosure Stmt	1806	1	240	240
		Total in USD ($)		**240**

Electronic Acknowledgement Receipt

EFS ID:	31522277
Application Number:	14692484
International Application Number:	
Confirmation Number:	3851
Title of Invention:	CORE BARREL HEAD ASSEMBLY WITH AN INTEGRATED SAMPLE ORIENTATION TOOL AND SYSTEM FOR USING SAME
First Named Inventor/Applicant Name:	CHRISTOPHER L. DRENTH
Customer Number:	23859
Filer:	Joseph P. Anderson
Filer Authorized By:	
Attorney Docket Number:	36362.0150U2-
Receipt Date:	17-JAN-2018
Filing Date:	21-APR-2015
Time Stamp:	12:27:58
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Transmittal Letter	Transmittal.pdf	123835 c31c5010ecdc064c01103f182326d450e88c0e83	no	2
Warnings:					

Information:					
2	Information Disclosure Statement (IDS) Form (SB08)	IDS.pdf	123817 71e25716278b6e2f08470130f85133a5074802eb	no	2
Warnings:					
Information:					
This is not an USPTO supplied IDS fillable form					
3	Foreign Reference	WO2008113127A1.pdf	1860967 a9a1155cd04ff1f0d2aebb41cdf58b08e567e5c8	no	49
Warnings:					
Information:					
4	Foreign Reference	GB2243173A.pdf	1843684 e2ac0628a5c7267d67cd5b1695ed5e19325e6b11	no	48
Warnings:					
Information:					
5	Other Reference-Patent/App/Search documents	36362_0150EP1_ESSR_2017_10_17.pdf	344960 c9d4d672a6d6c775d59e94c0fbcd87729c655c12	no	9
Warnings:					
Information:					
6	Fee Worksheet (SB06)	fee-info.pdf	30930 d948343f26c3a81fb71f397df6b10342ce1f857b	no	2
Warnings:					
Information:					
		Total Files Size (in bytes):	4328193		

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111

If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

PTO/SB/08a (07-09)
Approved for use through 07/31/2016. OMB 0651-0031
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

Substitute for form 1449/PTO

INFORMATION DISCLOSURE STATEMENT BY APPLICANT

(Use as many sheets as necessary)

Sheet 1 of 2

Complete if Known	
Application Number	14/692,484
Filing Date	April 21, 2015
First Named Inventor	Christopher L. Drenth
Art Unit	3676
Examiner Name	M. R. Wills, III
Attorney Docket Number	36362.0150U2-

U. S. PATENT DOCUMENTS

Examiner Initials*	Cite No.[1]	Document Number Number-Kind Code[2] *(if known)*	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear
	A	US-2,944,792-A	07-12-1960	Gros	

FOREIGN PATENT DOCUMENTS

Examiner Initials*	Cite No.[1]	Foreign Patent Document Country Code[3] Number[4] Kind Code[5] *(if known)*	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages Or Relevant Figures Appear	T[6]
	B	WO 2008/113127 A	09-25-2008	2iC Australia Pty Ltd.	Corresponds to EP 2134921-A1	
	C	GB-2243173-A	10-23-1991	Seafloors Eng Inc		

Examiner Signature		Date Considered	

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant. [1] Applicant's unique citation designation number (optional). [2] See Kinds Codes of USPTO Patent Documents at www.uspto.gov or MPEP 901.04. [3] Enter Office that issued the document, by the two-letter code (WIPO Standard ST.3). [4] For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. [5]Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. [6] Applicant is to place a check mark here if English language Translation is attached.

I hereby certify that this paper (along with any paper referred to as being attached or enclosed) is being transmitted via the Office electronic filing system in accordance with 37 CFR § 1.6(a)(4).

Dated: January 17, 2018 Signature: /Joseph P. Anderson, III/ (Joseph P. Anderson, III)

PTO/SB/08b (07-09)
Approved for use through 07/31/2016. OMB 0651-0031
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
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Substitute for form 1449/PTO

INFORMATION DISCLOSURE STATEMENT BY APPLICANT

(Use as many sheets as necessary)

Sheet	2	of	2

Complete if Known	
Application Number	14/692,484
Filing Date	April 21, 2015
First Named Inventor	Christopher L. Drenth
Art Unit	3676
Examiner Name	M. R. Wills, III
Attorney Docket Number	36362.0150U2-

NON PATENT LITERATURE DOCUMENTS

Examiner Initials*	Cite No.[1]	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc.), date, page(s), volume-issue number(s), publisher, city and/or country where published.	T[2]
	D	Extended European Search Report issued on October 17, 2017 by the European Patent Office for Application No. 15782230.5, which was filed on April 21, 2015 and published as EP 3134600 on March 1, 2017 (Inventor- Drenth et al.; Applicant- Longyear TM, Inc. et al.; Attorney Docket No.- 36362.0150EP1) (9 pages).	

Examiner Signature		Date Considered	

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

[1] Applicant's unique citation designation number (optional). [2] Applicant is to place a check mark here if English language Translation is attached.

Electronic Patent Application Fee Transmittal

Application Number:	14692484
Filing Date:	21-Apr-2015
Title of Invention:	CORE BARREL HEAD ASSEMBLY WITH AN INTEGRATED SAMPLE ORIENTATION TOOL AND SYSTEM FOR USING SAME
First Named Inventor/Applicant Name:	CHRISTOPHER L. DRENTH
Filer:	Joseph P. Anderson
Attorney Docket Number:	36362.0150U2-

Filed as Large Entity

Filing Fees for Utility under 35 USC 111(a)

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
Pages:				
Claims:				
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				
Extension-of-Time:				

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Miscellaneous:				
Submission- Information Disclosure Stmt	1806	1	240	240
		Total in USD ($)		**240**

Electronic Acknowledgement Receipt	
EFS ID:	31523029
Application Number:	14692484
International Application Number:	
Confirmation Number:	3851
Title of Invention:	CORE BARREL HEAD ASSEMBLY WITH AN INTEGRATED SAMPLE ORIENTATION TOOL AND SYSTEM FOR USING SAME
First Named Inventor/Applicant Name:	CHRISTOPHER L. DRENTH
Customer Number:	23859
Filer:	Joseph P. Anderson
Filer Authorized By:	
Attorney Docket Number:	36362.0150U2-
Receipt Date:	17-JAN-2018
Filing Date:	21-APR-2015
Time Stamp:	13:09:28
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment Type	CARD
Payment was successfully received in RAM	$240
RAM confirmation Number	011718INTEFSW13105600
Deposit Account	
Authorized User	
The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows:	

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Fee Worksheet (SB06)	fee-info.pdf	30931 0c2ac045b7f15fd1fadcf0a0339c71a26666f6b8	no	2

Warnings:	
Information:	
Total Files Size (in bytes):	30931

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111
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Electronic Patent Application Fee Transmittal

Application Number:	14692484
Filing Date:	21-Apr-2015
Title of Invention:	CORE BARREL HEAD ASSEMBLY WITH AN INTEGRATED SAMPLE ORIENTATION TOOL AND SYSTEM FOR USING SAME
First Named Inventor/Applicant Name:	CHRISTOPHER L. DRENTH
Filer:	Joseph P. Anderson
Attorney Docket Number:	36362.0150U2-

Filed as Large Entity

Filing Fees for Utility under 35 USC 111(a)

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
Pages:				
Claims:				
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				
Extension-of-Time:				

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Miscellaneous:				
Submission- Information Disclosure Stmt	1806	1	240	240
		Total in USD ($)		**240**

Electronic Acknowledgement Receipt

EFS ID:	31522541
Application Number:	14692484
International Application Number:	
Confirmation Number:	3851
Title of Invention:	CORE BARREL HEAD ASSEMBLY WITH AN INTEGRATED SAMPLE ORIENTATION TOOL AND SYSTEM FOR USING SAME
First Named Inventor/Applicant Name:	CHRISTOPHER L. DRENTH
Customer Number:	23859
Filer:	Joseph P. Anderson
Filer Authorized By:	
Attorney Docket Number:	36362.0150U2-
Receipt Date:	17-JAN-2018
Filing Date:	21-APR-2015
Time Stamp:	12:42:57
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Fee Worksheet (SB06)	fee-info.pdf	30929 10b7284c923f5a3f3644df95f2e12a3ccdf56b29	no	2

Warnings:

Information:	
Total Files Size (in bytes):	30929

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111

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New International Application Filed with the USPTO as a Receiving Office

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Issue Classification	Application/Control No.	Applicant(s)/Patent Under Reexamination
	14/692,484	DRENTH et al.
	Examiner	**Art Unit**
	MICHAEL R WILLS III	3676

CPC						
Symbol					**Type**	**Version**
E21B	/	25	/	16	F	2013-01-01

CPC Combination Sets								
Symbol					**Type**	**Set**	**Ranking**	**Version**
	/		/					

NONE		**Total Claims Allowed:**	
(Assistant Examiner)	(Date)	33	
/MICHAEL R WILLS III/ Primary Examiner, Art Unit 3676	30 October 2017	O.G. Print Claim(s)	O.G. Print Figure
(Primary Examiner)	(Date)	1	1

U.S. Patent and Trademark Office — Part of Paper No.: 20171030

Ex.2001 / IPR2023-00642 / Page 259 of 870
Reflex USA LLC v. Longyear TM, Inc. and Globaltech Corporation Pty Ltd.

Issue Classification	Application/Control No.	Applicant(s)/Patent Under Reexamination
	14/692,484	DRENTH et al.
	Examiner	**Art Unit**
	MICHAEL R WILLS III	3676

INTERNATIONAL CLASSIFICATION					
CLAIMED					
E21B	/	25	/	16	

NON-CLAIMED				
	/		/	

US ORIGINAL CLASSIFICATION	
CLASS	**SUBCLASS**

CROSS REFERENCES(S)						
CLASS	**SUBCLASS (ONE SUBCLASS PER BLOCK)**					

NONE		**Total Claims Allowed:**	
(Assistant Examiner)	(Date)	33	
/MICHAEL R WILLS III/ Primary Examiner, Art Unit 3676	30 October 2017	O.G. Print Claim(s)	O.G. Print Figure
(Primary Examiner)	(Date)	1	1

U.S. Patent and Trademark Office — Part of Paper No.: 20171030

Ex.2001 / IPR2023-00642 / Page 260 of 870
Reflex USA LLC v. Longyear TM, Inc. and Globaltech Corporation Pty Ltd.

Issue Classification	Application/Control No.	Applicant(s)/Patent Under Reexamination
	14/692,484	DRENTH et al.
	Examiner	**Art Unit**
	MICHAEL R WILLS III	3676

☐ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47

CLAIMS

Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original
1	1	10	16	19	25	28	34								
2	6	11	17	20	26	29	35								
3	7	12	18	21	27	30	36								
4	10	13	19	22	28	31	37								
5	11	14	20	23	29	32	38								
6	12	15	21	24	30	33	39								
7	13	16	22	25	31										
8	14	17	23	26	32										
9	15	18	24	27	33										

NONE		**Total Claims Allowed:**	
(Assistant Examiner)	(Date)	33	
/MICHAEL R WILLS III/ Primary Examiner, Art Unit 3676	30 October 2017	O.G. Print Claim(s)	O.G. Print Figure
(Primary Examiner)	(Date)	1	1

U.S. Patent and Trademark Office

Part of Paper No.: 20171030

Ex.2001 / IPR2023-00642 / Page 261 of 870
Reflex USA LLC v. Longyear TM, Inc. and Globaltech Corporation Pty Ltd.

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UNITED STATES DEPARTMENT OF COMMERCE
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Address: COMMISSIONER FOR PATENTS
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Alexandria, Virginia 22313-1450
www.uspto.gov

BIB DATA SHEET

CONFIRMATION NO. 3851

SERIAL NUMBER	FILING or 371(c) DATE	CLASS	GROUP ART UNIT	ATTORNEY DOCKET NO.
14/692,484	04/21/2015 RULE	175	3676	36362.0150U2-

APPLICANTS

LONGYEAR TM, INC., South Jordan, UT;
GLOBALTECH CORPORATION PTY LTD, CANNING VALE, AUSTRALIA;

INVENTORS

CHRISTOPHER L. DRENTH, Ontario, CANADA;
GORDON STEWART, Claremont, AUSTRALIA;
KHALED HEJLEH, Peppermint Grove, AUSTRALIA;

**** CONTINUING DATA ***************************

This appln claims benefit of 61/982,052 04/21/2014

**** FOREIGN APPLICATIONS ***************************

**** IF REQUIRED, FOREIGN FILING LICENSE GRANTED ****

05/01/2015

Foreign Priority claimed	☐ Yes ☑ No	☐ Met after Allowance	STATE OR COUNTRY	SHEETS DRAWINGS	TOTAL CLAIMS	INDEPENDENT CLAIMS
35 USC 119(a-d) conditions met	☐ Yes ☑ No		CANADA	12	33	1
Verified and Acknowledged	/MICHAEL R WILLS III/ Examiner's Signature	Initials				

ADDRESS

Ballard Spahr LLP
SUITE 1000
999 PEACHTREE STREET
ATLANTA, GA 30309-3915
UNITED STATES

TITLE

Core Barrel Head Assembly With An Integrated Sample Orientation Tool And System For Using Same

FILING FEE RECEIVED	FEES: Authority has been given in Paper	☐ All Fees
2780	No._____ to charge/credit DEPOSIT ACCOUNT	☐ 1.16 Fees (Filing)
	No._____ for following:	☐ 1.17 Fees (Processing Ext. of time)
		☐ 1.18 Fees (Issue)
		☐ Other _____
		☐ Credit

EAST Search History

EAST Search History (Prior Art)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	Time Stamp
L1	1	"14962484"	US-PGPUB; USPAT; USOCR	ADJ	ON	2017/10/30 11:20
L2	12	"5601152"	US-PGPUB; USPAT; USOCR	ADJ	ON	2017/10/30 11:22
L3	1	"14692484"	US-PGPUB; USPAT; USOCR	ADJ	ON	2017/10/30 11:30
L4	203	(E21B25/16).cpc.	US-PGPUB; USPAT; USOCR	ADJ	ON	2017/10/30 11:35
L5	0	core barrel and cavity and electronic intrument and sensor and power source and core and window	US-PGPUB; USPAT; USOCR	ADJ	ON	2017/10/30 11:37
L6	1	core barrel and cavity and electronic instrument and sensor and power source and core and window	US-PGPUB; USPAT; USOCR	ADJ	ON	2017/10/30 11:37
L9	1	core barrel and cavity and orientation and sensor and power source and core and window	US-PGPUB; USPAT; USOCR	ADJ	ON	2017/10/30 11:38
L10	4551	cavity and orientation and sensor and power source and core and window	US-PGPUB; USPAT; USOCR	ADJ	ON	2017/10/30 11:38
L14	141	electronic instrument and cavity and orientation and sensor and power source and core and window	US-PGPUB; USPAT; USOCR	ADJ	ON	2017/10/30 11:39
S1	1	"14692484"	US-PGPUB; USPAT; USOCR	ADJ	ON	2017/06/16 07:57
S2	79	(("DRENTH") near3 ("CHRISTOPHER")).INV.	US-PGPUB; USPAT; USOCR	ADJ	ON	2017/08/10 12:08
S3	145	(("STEWART") near3 ("GORDON")).INV.	US-PGPUB; USPAT; USOCR	ADJ	ON	2017/08/10 12:21

S4	47	(("STEWART") near3 ("GORDON")).INV.	EPO; JPO; DERWENT	ADJ	ON	2017/08/10 12:21
S5	7	(("HEJLEH") near3 ("KHALED")).INV.	US-PGPUB; USPAT; USOCR	ADJ	ON	2017/08/10 14:08
S6	2	("20120145461" | "6732818").PN.	US-PGPUB; USPAT; USOCR	ADJ	ON	2017/08/10 15:04
S7	201	(E21B25/16).cpc.	US-PGPUB; USPAT; USOCR	ADJ	ON	2017/08/10 15:07
S8	440855	(power source or battery) and (body or housing)and (instrument or sensor)	US-PGPUB; USPAT; USOCR	ADJ	ON	2017/08/10 16:21
S9	0	WO "2008113127"	US-PGPUB; USPAT; USOCR	ADJ	ON	2017/08/11 10:41
S10	3	"2008113127"	US-PGPUB; USPAT; USOCR; DERWENT	ADJ	ON	2017/08/11 10:41
S11	201	(E21B25/16).cpc.	US-PGPUB; USPAT; USOCR	ADJ	ON	2017/08/11 11:12
S12	48	S11 and (battery or power source)	US-PGPUB; USPAT; USOCR	ADJ	ON	2017/08/11 11:12
S13	3	(US-20150300162-$ or US-20150136488-$ or US-20150029035-$).did.	US-PGPUB	ADJ	ON	2017/08/11 11:15
S14	3	S13 and (battery or power source)	US-PGPUB; USPAT; USOCR	ADJ	ON	2017/08/11 11:15
S15	3	S13 and (battery or power source or power supply)	US-PGPUB; USPAT; USOCR	ADJ	ON	2017/08/11 11:19
S16	48	S11 and (battery or power source or power supply)	US-PGPUB; USPAT; USOCR	ADJ	ON	2017/08/11 11:19
S17	21	S11 and window	US-PGPUB; USPAT; USOCR	ADJ	ON	2017/08/11 11:45
S18	0	702/2.cpc.	US-PGPUB; USPAT; USOCR	ADJ	ON	2017/08/11 11:46
S19	921	702/2.ccls.	US-	ADJ	ON	2017/08/11

Ex.2001 / IPR2023-00642 / Page 264 of 870
Reflex USA LLC v. Longyear TM, Inc. and Globaltech Corporation Pty Ltd.

			PGPUB; USPAT; USOCR			11:46
S20	236	S19 and window	US-PGPUB; USPAT; USOCR	ADJ	ON	2017/08/11 11:46
S21	8	S19 and window and core$3 and orientat$3	US-PGPUB; USPAT; USOCR	ADJ	ON	2017/08/11 11:47
S22	606	E21B$.cpc.and window and core$3 and orientat$3 and (battery or power source or power supply)	US-PGPUB; USPAT; USOCR	ADJ	ON	2017/08/11 11:48
S23	606	E21B$.cpc. and window and core$3 and orientat$3 and (battery or power source or power supply)	US-PGPUB; USPAT; USOCR	ADJ	ON	2017/08/11 11:48
S24	263	E21B$.cpc. and window and core$3 and orientat$3 and (battery or power source or power supply) and wireline	US-PGPUB; USPAT; USOCR	ADJ	ON	2017/08/11 11:54
S25	300	E21B$.cpc. and window and core$3 and orientat$3 and (battery or power source or power supply) and (wireline or wire line)	US-PGPUB; USPAT; USOCR	ADJ	ON	2017/08/11 11:54
S26	346	E21B$.cpc. and window and cor$3 and orientat$3 and (battery or power source or power supply) and (wireline or wire line)	US-PGPUB; USPAT; USOCR	ADJ	ON	2017/08/11 12:07
S27	1730	window and cor$3 and orientat$3 and (battery or power source or power supply) and (wireline or wire line)	US-PGPUB; USPAT; USOCR	ADJ	ON	2017/08/11 12:08
S28	114	S27 AND ((E21B17/028 OR E21B47/09 OR E21B25/16).CPC.)	US-PGPUB; USPAT; USOCR	ADJ	ON	2017/08/11 12:20
S29	2	("20120145461" | "6732818").PN.	US-PGPUB; USPAT; USOCR	ADJ	ON	2017/08/12 14:07
S30	0	("2012/0145461").URPN.	USPAT	ADJ	ON	2017/08/12 14:07
S31	20	("1701724" | "1773915" | "2120240" | "2489566" | "2974739" | "3059707" | "3148740" | "3207239" | "4128134" | "4558749" | "4883131").PN. OR ("6732818").URPN.	US-PGPUB; USPAT; USOCR	ADJ	ON	2017/08/12 14:07
S32	28	("20040036474" | "3618221" | "3875796" | "4128134" | "4311201" | "4389792" | "4765414" | "4883131" | "5048619" | "5052502" | "5105894" | "5310013" | "6006844" | "6082453" | "6412575" | "6592875" | "6659196" | "6732818" | "6871410" | "7296638").PN. OR ("7584055").URPN.	US-PGPUB; USPAT; USOCR	ADJ	ON	2017/08/12 14:07
S33	38	("1773915" | "2652232" | "3115196" |	US-	ADJ	ON	2017/08/12

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Reflex USA LLC v. Longyear TM, Inc. and Globaltech Corporation Pty Ltd.

		"5957221").PN. OR ("7296638").URPN.	PGPUB; USPAT; USOCR			14:08
S34	846	E21B25/00.cpc.	US-PGPUB; USPAT; USOCR	ADJ	ON	2017/08/12 14:09
S35	9	S34 and window and core$3 and orientat$3	US-PGPUB; USPAT; USOCR	ADJ	ON	2017/08/12 14:09
S36	69	S34 and core$3 and orientat$3	US-PGPUB; USPAT; USOCR	ADJ	ON	2017/08/12 14:09
S37	38	("1773915" | "2652232" | "3115196" | "5957221").PN. OR ("7296638").URPN.	US-PGPUB; USPAT; USOCR	ADJ	ON	2017/08/12 14:10
S38	101	("2489566" | "2735652" | "2820610" | "3059707" | "3127943" | "3481412" | "3548958" | "4601354" | "4765414" | "4815342" | "4955438" | "4981183" | "4982802" | "5009273" | "5010765" | "5010789" | "5020612" | "5029653" | "5038873" | "5042596" | "5090492" | "5099934" | "5103921" | "5109935" | "5111892" | "5119892" | "5131478" | "5165494" | "5178222" | "5253720" | "5322135" | "5339915" | "5351765" | "5448227" | "5568838").PN. OR ("6006844").URPN.	US-PGPUB; USPAT; USOCR	ADJ	ON	2017/08/12 14:11
S39	40	("2820610" | "3059707" | "3346059" | "4515225" | "4562560" | "4715022" | "4765414").PN. OR ("4955438").URPN.	US-PGPUB; USPAT; USOCR	ADJ	ON	2017/08/12 14:11
S40	0	("2015/0300162").URPN.	USPAT	ADJ	ON	2017/08/12 14:11
S41	0	("2015/0136488").URPN.	USPAT	ADJ	ON	2017/08/12 14:11
S42	0	("2015/0029035").URPN.	USPAT	ADJ	ON	2017/08/12 14:11

EAST Search History (Interference)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	Time Stamp
L7	0	core barrel and cavity and electronic instrument and sensor and power source and core and window	USPAT	ADJ	ON	2017/10/30 11:37
L8	0	core barrel and cavity and orientation and sensor and power source and core and window	USPAT	ADJ	ON	2017/10/30 11:38
L11	1848	cavity and orientation and sensor and power source and core and window	USPAT	ADJ	ON	2017/10/30 11:38
L13	72	electronic instrument and cavity and orientation and sensor and power source and core and window	USPAT	ADJ	ON	2017/10/30 11:39

10/30/2017 11:40:41 AM
C:\Users\mwills1\Documents\EAST\Workspaces\14692484.wsp

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Reflex USA LLC v. Longyear TM, Inc. and Globaltech Corporation Pty Ltd.

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

NOTICE OF ALLOWANCE AND FEE(S) DUE

23859 7590 11/08/2017

Ballard Spahr LLP
SUITE 1000
999 PEACHTREE STREET
ATLANTA, GA 30309-3915

EXAMINER	
WILLS III, MICHAEL R	
ART UNIT	PAPER NUMBER
3676	

DATE MAILED: 11/08/2017

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
14/692,484	04/21/2015	CHRISTOPHER L. DRENTH	36362.0150U2-	3851

TITLE OF INVENTION: CORE BARREL HEAD ASSEMBLY WITH AN INTEGRATED SAMPLE ORIENTATION TOOL AND SYSTEM FOR USING SAME

APPLN. TYPE	ENTITY STATUS	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	UNDISCOUNTED	$960	$0	$0	$960	02/08/2018

THE APPLICATION IDENTIFIED ABOVE HAS BEEN EXAMINED AND IS ALLOWED FOR ISSUANCE AS A PATENT. PROSECUTION ON THE MERITS IS CLOSED. THIS NOTICE OF ALLOWANCE IS NOT A GRANT OF PATENT RIGHTS. THIS APPLICATION IS SUBJECT TO WITHDRAWAL FROM ISSUE AT THE INITIATIVE OF THE OFFICE OR UPON PETITION BY THE APPLICANT. SEE 37 CFR 1.313 AND MPEP 1308.

THE ISSUE FEE AND PUBLICATION FEE (IF REQUIRED) MUST BE PAID WITHIN THREE MONTHS FROM THE MAILING DATE OF THIS NOTICE OR THIS APPLICATION SHALL BE REGARDED AS ABANDONED. THIS STATUTORY PERIOD CANNOT BE EXTENDED. SEE 35 U.S.C. 151. THE ISSUE FEE DUE INDICATED ABOVE DOES NOT REFLECT A CREDIT FOR ANY PREVIOUSLY PAID ISSUE FEE IN THIS APPLICATION. IF AN ISSUE FEE HAS PREVIOUSLY BEEN PAID IN THIS APPLICATION (AS SHOWN ABOVE), THE RETURN OF PART B OF THIS FORM WILL BE CONSIDERED A REQUEST TO REAPPLY THE PREVIOUSLY PAID ISSUE FEE TOWARD THE ISSUE FEE NOW DUE.

HOW TO REPLY TO THIS NOTICE:

I. Review the ENTITY STATUS shown above. If the ENTITY STATUS is shown as SMALL or MICRO, verify whether entitlement to that entity status still applies.

If the ENTITY STATUS is the same as shown above, pay the TOTAL FEE(S) DUE shown above.

If the ENTITY STATUS is changed from that shown above, on PART B - FEE(S) TRANSMITTAL, complete section number 5 titled "Change in Entity Status (from status indicated above)".

For purposes of this notice, small entity fees are 1/2 the amount of undiscounted fees, and micro entity fees are 1/2 the amount of small entity fees.

II. PART B - FEE(S) TRANSMITTAL, or its equivalent, must be completed and returned to the United States Patent and Trademark Office (USPTO) with your ISSUE FEE and PUBLICATION FEE (if required). If you are charging the fee(s) to your deposit account, section "4b" of Part B - Fee(s) Transmittal should be completed and an extra copy of the form should be submitted. If an equivalent of Part B is filed, a request to reapply a previously paid issue fee must be clearly made, and delays in processing may occur due to the difficulty in recognizing the paper as an equivalent of Part B.

III. All communications regarding this application must give the application number. Please direct all communications prior to issuance to Mail Stop ISSUE FEE unless advised to the contrary.

IMPORTANT REMINDER: Maintenance fees are due in utility patents issuing on applications filed on or after Dec. 12, 1980. It is patentee's responsibility to ensure timely payment of maintenance fees when due. More information is available at www.uspto.gov/PatentMaintenanceFees.

PTOL-85 (Rev. 02/11)

PART B - FEE(S) TRANSMITTAL

Complete and send this form, together with applicable fee(s), to: Mail **Mail Stop ISSUE FEE**
Commissioner for Patents
P.O. Box 1450
Alexandria, Virginia 22313-1450
or Fax (571)-273-2885

INSTRUCTIONS: This form should be used for transmitting the ISSUE FEE and PUBLICATION FEE (if required). Blocks 1 through 5 should be completed where appropriate. All further correspondence including the Patent, advance orders and notification of maintenance fees will be mailed to the current correspondence address as indicated unless corrected below or directed otherwise in Block 1, by (a) specifying a new correspondence address; and/or (b) indicating a separate "FEE ADDRESS" for maintenance fee notifications.

CURRENT CORRESPONDENCE ADDRESS (Note: Use Block 1 for any change of address)

23859 7590 11/08/2017
Ballard Spahr LLP
SUITE 1000
999 PEACHTREE STREET
ATLANTA, GA 30309-3915

Note: A certificate of mailing can only be used for domestic mailings of the Fee(s) Transmittal. This certificate cannot be used for any other accompanying papers. Each additional paper, such as an assignment or formal drawing, must have its own certificate of mailing or transmission.

Certificate of Mailing or Transmission
I hereby certify that this Fee(s) Transmittal is being deposited with the United States Postal Service with sufficient postage for first class mail in an envelope addressed to the Mail Stop ISSUE FEE address above, or being facsimile transmitted to the USPTO (571) 273-2885, on the date indicated below.

(Depositor's name)
(Signature)
(Date)

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
14/692,484	04/21/2015	CHRISTOPHER L. DRENTH	36362.0150U2-	3851

TITLE OF INVENTION: CORE BARREL HEAD ASSEMBLY WITH AN INTEGRATED SAMPLE ORIENTATION TOOL AND SYSTEM FOR USING SAME

APPLN. TYPE	ENTITY STATUS	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	UNDISCOUNTED	$960	$0	$0	$960	02/08/2018

EXAMINER	ART UNIT	CLASS-SUBCLASS
WILLS III, MICHAEL R	3676	175-044000

1. Change of correspondence address or indication of "Fee Address" (37 CFR 1.363).
- ❑ Change of correspondence address (or Change of Correspondence Address form PTO/SB/122) attached.
- ❑ "Fee Address" indication (or "Fee Address" Indication form PTO/SB/47; Rev 03-02 or more recent) attached. **Use of a Customer Number is required.**

2. For printing on the patent front page, list
(1) The names of up to 3 registered patent attorneys or agents OR, alternatively,
(2) The name of a single firm (having as a member a registered attorney or agent) and the names of up to 2 registered patent attorneys or agents. If no name is listed, no name will be printed.
1 _____
2 _____
3 _____

3. ASSIGNEE NAME AND RESIDENCE DATA TO BE PRINTED ON THE PATENT (print or type)

PLEASE NOTE: Unless an assignee is identified below, no assignee data will appear on the patent. If an assignee is identified below, the document has been filed for recordation as set forth in 37 CFR 3.11. Completion of this form is NOT a substitute for filing an assignment.

(A) NAME OF ASSIGNEE (B) RESIDENCE: (CITY and STATE OR COUNTRY)

Please check the appropriate assignee category or categories (will not be printed on the patent) : ❑ Individual ❑ Corporation or other private group entity ❑ Government

4a. The following fee(s) are submitted:
- ❑ Issue Fee
- ❑ Publication Fee (No small entity discount permitted)
- ❑ Advance Order - # of Copies _____

4b. Payment of Fee(s): **(Please first reapply any previously paid issue fee shown above)**
- ❑ A check is enclosed.
- ❑ Payment by credit card. Form PTO-2038 is attached.
- ❑ The director is hereby authorized to charge the required fee(s), any deficiency, or credits any overpayment, to Deposit Account Number _____ (enclose an extra copy of this form).

5. **Change in Entity Status** (from status indicated above)
- ❑ Applicant certifying micro entity status. See 37 CFR 1.29 — NOTE: Absent a valid certification of Micro Entity Status (see forms PTO/SB/15A and 15B), issue fee payment in the micro entity amount will not be accepted at the risk of application abandonment.
- ❑ Applicant asserting small entity status. See 37 CFR 1.27 — NOTE: If the application was previously under micro entity status, checking this box will be taken to be a notification of loss of entitlement to micro entity status.
- ❑ Applicant changing to regular undiscounted fee status. — NOTE: Checking this box will be taken to be a notification of loss of entitlement to small or micro entity status, as applicable.

NOTE: This form must be signed in accordance with 37 CFR 1.31 and 1.33. See 37 CFR 1.4 for signature requirements and certifications.

Authorized Signature _____ Date _____

Typed or printed name _____ Registration No. _____

PTOL-85 Part B (10-13) Approved for use through 10/31/2013. OMB 0651-0033 U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

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Reflex USA LLC v. Longyear TM, Inc. and Globaltech Corporation Pty Ltd.

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
14/692,484	04/21/2015	CHRISTOPHER L. DRENTH	36362.0150U2-	3851

23859 7590 11/08/2017

Ballard Spahr LLP
SUITE 1000
999 PEACHTREE STREET
ATLANTA, GA 30309-3915

EXAMINER	
WILLS III, MICHAEL R	
ART UNIT	PAPER NUMBER
3676	

DATE MAILED: 11/08/2017

Determination of Patent Term Adjustment under 35 U.S.C. 154 (b)
(Applications filed on or after May 29, 2000)

The Office has discontinued providing a Patent Term Adjustment (PTA) calculation with the Notice of Allowance.

Section 1(h)(2) of the AIA Technical Corrections Act amended 35 U.S.C. 154(b)(3)(B)(i) to eliminate the requirement that the Office provide a patent term adjustment determination with the notice of allowance. See Revisions to Patent Term Adjustment, 78 Fed. Reg. 19416, 19417 (Apr. 1, 2013). Therefore, the Office is no longer providing an initial patent term adjustment determination with the notice of allowance. The Office will continue to provide a patent term adjustment determination with the Issue Notification Letter that is mailed to applicant approximately three weeks prior to the issue date of the patent, and will include the patent term adjustment on the patent. Any request for reconsideration of the patent term adjustment determination (or reinstatement of patent term adjustment) should follow the process outlined in 37 CFR 1.705.

Any questions regarding the Patent Term Extension or Adjustment determination should be directed to the Office of Patent Legal Administration at (571)-272-7702. Questions relating to issue and publication fee payments should be directed to the Customer Service Center of the Office of Patent Publication at 1-(888)-786-0101 or (571)-272-4200.

OMB Clearance and PRA Burden Statement for PTOL-85 Part B

The Paperwork Reduction Act (PRA) of 1995 requires Federal agencies to obtain Office of Management and Budget approval before requesting most types of information from the public. When OMB approves an agency request to collect information from the public, OMB (i) provides a valid OMB Control Number and expiration date for the agency to display on the instrument that will be used to collect the information and (ii) requires the agency to inform the public about the OMB Control Number's legal significance in accordance with 5 CFR 1320.5(b).

The information collected by PTOL-85 Part B is required by 37 CFR 1.311. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, Virginia 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, Virginia 22313-1450. Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

Privacy Act Statement

The Privacy Act of 1974 (P.L. 93-579) requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether disclosure of these records is required by the Freedom of Information Act.
2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.
3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.
4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).
5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.
6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).
7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.
8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspection or an issued patent.
9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

Notice of Allowability	Application No. 14/692,484	Applicant(s) DRENTH et al.	
	Examiner MICHAEL R WILLS III	Art Unit 3676	AIA Status Yes

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address--

All claims being allowable, PROSECUTION ON THE MERITS IS (OR REMAINS) CLOSED in this application. If not included herewith (or previously mailed), a Notice of Allowance (PTOL-85) or other appropriate communication will be mailed in due course. **THIS NOTICE OF ALLOWABILITY IS NOT A GRANT OF PATENT RIGHTS.** This application is subject to withdrawal from issue at the initiative of the Office or upon petition by the applicant. See 37 CFR 1.313 and MPEP 1308.

1. ☑ This communication is responsive to remarks filed October 18, 2017 .
   ☐ A declaration(s)/affidavit(s) under **37 CFR 1.130(b)** was/were filed on _____ .

2. ☐ An election was made by the applicant in response to a restriction requirement set forth during the interview on _____; the restriction requirement and election have been incorporated into this action.

3. ☑ The allowed claim(s) is/are 1,6-7 and 10-39 . As a result of the allowed claim(s), you may be eligible to benefit from the **Patent Prosecution Highway** program at a participating intellectual property office for the corresponding application. For more information , please see **http://www.uspto.gov/patents/init_events/pph/index.jsp** or send an inquiry to **PPHfeedback@uspto.gov.**

4. ☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

   Certified copies:

   a) ☐ All b) ☐ Some *c) ☐ None of the:

   1. ☐ Certified copies of the priority documents have been received.
   2. ☐ Certified copies of the priority documents have been received in Application No. _____ .
   3. ☐ Copies of the certified copies of the priority documents have been received in this national stage application from the International Bureau (PCT Rule 17.2(a)).

   * Certified copies not received: _____ .

Applicant has THREE MONTHS FROM THE "MAILING DATE" of this communication to file areply complying with the requirements noted below. Failure to timely comply will result in ABANDONMENT of this application.
THIS THREE-MONTH PERIOD IS NOT EXTENDABLE.

5. ☐ CORRECTED DRAWINGS (as "replacement sheets") must be submitted.
   ☐ including changes required by the attached Examiner's Amendment / Comment or in the Office action of Paper No./Mail Date _____ .

   Identifying indicia such as the application number (see 37 CFR 1.84(c)) should be written on the drawings in the front (not the back) of each sheet. Replacement sheet(s) should be labeled as such in the header according to 37 CFR 1.121(d).

6. ☐ DEPOSIT OF and/or INFORMATION about the deposit of BIOLOGICAL MATERIAL must be submitted. Note the attached Examiner's comment regarding REQUIREMENT FOR THE DEPOSIT OF BIOLOGICAL MATERIAL.

Attachment(s)

1. ☐ Notice of References Cited (PTO-892)
2. ☑ Information Disclosure Statements (PTO/SB/08), Paper No./Mail Date _____
3. ☐ Examiner's Comment Regarding Requirement for Deposit of Biological Material _____
4. ☐ Interview Summary (PTO-413), Paper No./Mail Date. _____ .
5. ☐ Examiner's Amendment/Comment
6. ☐ Examiner's Statement of Reasons for Allowance
7. ☐ Other _____ .

/MICHAEL R WILLS III/
Primary Examiner, Art Unit 3676

PTO/SB/08a (07-09)
Approved for use through 07/31/2016. OMB 0651-0031
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
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Substitute for form 1449/PTO

INFORMATION DISCLOSURE STATEMENT BY APPLICANT

(Use as many sheets as necessary)

Sheet 1 of 2

Complete if Known	
Application Number	14/692,484
Filing Date	April 21, 2015
First Named Inventor	Christopher L. Drenth
Art Unit	3676
Examiner Name	Michael R. Wills III
Attorney Docket Number	36362.0150U2-

U. S. PATENT DOCUMENTS

Examiner Initials*	Cite No.[1]	Document Number Number-Kind Code[2] *(if known)*	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear
	A	US-5,601,152	02-11-1997	Harrison	

FOREIGN PATENT DOCUMENTS

Examiner Initials*	Cite No.[1]	Foreign Patent Document Country Code[3]-Number[4]-Kind Code[5] *(if known)*	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages Or Relevant Figures Appear	T[6]
	A	WO-2006/024111	03-09-2006	AUSTRALIAN MUD COMPANY LTD		
	B	WO-2007/137356	12-06-2007	2IC AUSTRALIA PTY LTD		
	C	WO-2010/094060	08-26-2010	IMDEX TECHNOLOGY AUSTRALIA PTY		
	D	WO-2013/040641	03-28-2013	IMDEX GLOBAL BV		
	E	WO-2013/126955	09-06-2013	GLOBALTECH CORP PTY LTD		
	F	WO-2014/089618	06-19-2014	2IC AUSTRALIA PTY LTD		

Examiner Signature		Date Considered	

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant. [1] Applicant's unique citation designation number (optional). [2] See Kinds Codes of USPTO Patent Documents at www.uspto.gov or MPEP 901.04. [3] Enter Office that issued the document, by the two-letter code (WIPO Standard ST.3). [4] For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. [5]Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. [6] Applicant is to place a check mark here if English language Translation is attached.

I hereby certify that this paper (along with any paper referred to as being attached or enclosed) is being transmitted via the Office electronic filing system in accordance with 37 CFR § 1.6(a)(4).

Dated: October 23, 2017 Electronic Signature: /Joseph P. Anderson, III/ (Joseph P. Anderson, III)

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /M.R.W/

PTO/SB/08b (07-09)
Approved for use through 07/31/2016. OMB 0651-0031
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

Substitute for form 1449/PTO

INFORMATION DISCLOSURE STATEMENT BY APPLICANT

(Use as many sheets as necessary)

Sheet	2	of	2

Complete if Known	
Application Number	14/692,484
Filing Date	April 21, 2015
First Named Inventor	Christopher L. Drenth
Art Unit	3676
Examiner Name	Michael R. Wills III
Attorney Docket Number	36362.0150U2-

NON PATENT LITERATURE DOCUMENTS

Examiner Initials*	Cite No.[1]	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc.), date, page(s), volume-issue number(s), publisher, city and/or country where published.	T[2]
	A	Third Party Observations dated August 17, 2016 for International Patent Application No. PCT/US2015/026907 (Applicant- LONGYEAR TM, INC.) (42 pages)	

Examiner Signature	/MICHAEL R WILLS III/	Date Considered	10/30/2017

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

[1] Applicant's unique citation designation number (optional). [2] Applicant is to place a check mark here if English language Translation is attached.

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /M.R.W/

Search Notes	Application/Control No.	Applicant(s)/Patent Under Reexamination
	14/692,484	DRENTH et al.
	Examiner	Art Unit
	MICHAEL R WILLS III	3676

CPC - Searched*		
Symbol	Date	Examiner
E21B25/16	8/12/17	MW

CPC Combination Sets - Searched*		
Symbol	Date	Examiner

US Classification - Searched*			
Class	Subclass	Date	Examiner

* See search history printout included with this form or the SEARCH NOTES box below to determine the scope of the search.

Search Notes		
Search Notes	Date	Examiner
Invetor Name Search	8/12/17	MW
Forward/Backward Search	8/12/17	MW
See East Search History	8/12/17	MW
texted searched classes E21B17/028, E21B47/09	8/12/17	MW
Updated Search	10/30/2017	MW

Interference Search			
US Class/CPC Symbol	US Subclass/CPC Group	Date	Examiner
	See East Search History	10/30/2017	MW

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Reflex USA LLC v. Longyear TM, Inc. and Globaltech Corporation Pty Ltd.

PTO/SB/08a (07-09)
Approved for use through 07/31/2016. OMB 0651-0031
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
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Substitute for form 1449/PTO

INFORMATION DISCLOSURE STATEMENT BY APPLICANT

(Use as many sheets as necessary)

Sheet 1 of 2

Complete if Known	
Application Number	14/692,484
Filing Date	April 21, 2015
First Named Inventor	Christopher L. Drenth
Art Unit	3676
Examiner Name	Michael R. Wills III
Attorney Docket Number	36362.0150U2-

U. S. PATENT DOCUMENTS

Examiner Initials*	Cite No.[1]	Document Number Number-Kind Code[2] *(if known)*	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear
	A	US-5,601,152	02-11-1997	Harrison	

FOREIGN PATENT DOCUMENTS

Examiner Initials*	Cite No.[1]	Foreign Patent Document Country Code[3] Number[4] Kind Code[5] *(if known)*	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages Or Relevant Figures Appear	T[6]
	A	WO-2006/024111	03-09-2006	AUSTRALIAN MUD COMPANY LTD		
	B	WO-2007/137356	12-06-2007	2IC AUSTRALIA PTY LTD		
	C	WO-2010/094060	08-26-2010	IMDEX TECHNOLOGY AUSTRALIA PTY		
	D	WO-2013/040641	03-28-2013	IMDEX GLOBAL BV		
	E	WO-2013/126955	09-06-2013	GLOBALTECH CORP PTY LTD		
	F	WO-2014/089618	06-19-2014	2IC AUSTRALIA PTY LTD		

Examiner Signature		Date Considered	

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant. [1] Applicant's unique citation designation number (optional). [2] See Kinds Codes of USPTO Patent Documents at www.uspto.gov or MPEP 901.04. [3] Enter Office that issued the document, by the two-letter code (WIPO Standard ST.3). [4] For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. [5]Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. [6] Applicant is to place a check mark here if English language Translation is attached.

I hereby certify that this paper (along with any paper referred to as being attached or enclosed) is being transmitted via the Office electronic filing system in accordance with 37 CFR § 1.6(a)(4).

Dated: October 23, 2017 Electronic Signature: /Joseph P. Anderson, III/ (Joseph P. Anderson, III)

PTO/SB/08b (07-09)
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INFORMATION DISCLOSURE STATEMENT BY APPLICANT

(Use as many sheets as necessary)

Sheet	2	of	2	Attorney Docket Number	36362.0150U2-

Complete if Known	
Application Number	14/692,484
Filing Date	April 21, 2015
First Named Inventor	Christopher L. Drenth
Art Unit	3676
Examiner Name	Michael R. Wills III

NON PATENT LITERATURE DOCUMENTS

Examiner Initials*	Cite No.[1]	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc.), date, page(s), volume-issue number(s), publisher, city and/or country where published.	T[2]
	A	Third Party Observations dated August 17, 2016 for International Patent Application No. PCT/US2015/026907 (Applicant- LONGYEAR TM, INC.) (42 pages)	

Examiner Signature		Date Considered	

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

[1] Applicant's unique citation designation number (optional). [2] Applicant is to place a check mark here if English language Translation is attached.

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Dated: October 23, 2017
Electronic Signature for Joseph P. Anderson, III /Joseph P. Anderson, III/

ATTORNEY DOCKET NO. 36362.0150U2-
VIA EFS-WEB
PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of	)	
	)	
CHRISTOPHER L. DRENTH, ET AL.	)	Art Unit: 3676
	)	
Application No.: 14/692,484	)	Examiner: Michael R. Wills III
	)	
Filing Date: April 21, 2015	)	Confirmation No.: 3851
	)	
For: **CORE BARREL HEAD ASSEMBLY WITH AN INTEGRATED SAMPLE ORIENTATION TOOL AND SYSTEM FOR USING SAME**	)	

SUPPLEMENTAL INFORMATION DISCLOSURE STATEMENT

MAIL STOP AMENDMENT
Commissioner for Patents
P. O. Box 1450
Alexandria, VA 22313-1450

BALLARD SPAHR LLP
Customer No. 23859

October 23, 2017

Commissioner:

Pursuant to the requirements set forth in 37 C.F.R. § 1.56, Applicant now submits a list of documents known to Applicant or Applicant's attorneys. Pursuant to 37 C.F.R. § 1.98(a)(2)(iv), and for the Examiner's review, Applicant has enclosed (1) copies of documents from the prosecution of related non-U.S. patent applications, (2) copies of non-U.S. patents or non-U.S. patent application publications. In accordance with 37 C.F.R. § 1.98(a)(2), copies of any cited U.S. patent or U.S. patent application publication documents are not enclosed.

Regarding the documents from the prosecution of related non-U.S. patent applications, Applicant has identified the prosecution record of non-U.S. patent applications as the source for each document. The information provided mirrors the requirements for cited non-U.S. patent applications as set forth by 37 C.F.R. § 1.98(b).

Applicant respectfully requests consideration of all documents submitted in the present Supplemental Information Disclosure Statement and List and entry into the record for the present application (Application No. 14/692,484).

Pursuant to 37 C.F.R. § 1.97(c)(2), Applicant submits that this document is timely filed in that the Patent and Trademark Office has not yet mailed to Applicant a final action on the merits, a notice of allowance, or any action that otherwise closes prosecution. With this Supplemental Information

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Reflex USA LLC v. Longyear TM, Inc. and Globaltech Corporation Pty Ltd.

Disclosure Statement, Applicant submits a credit card payment in the amount of $180 pursuant to 37 C.F.R. § 1.17(p). Applicant submits that this is the correct fee due; however, Applicant hereby authorizes the Commissioner to charge to Deposit Account No. 14-0629 any fee that may be required to effect the consideration and entry of this Supplemental Information Disclosure Statement and List and the references contained therein.

Respectfully submitted,

Electronic signature: /Joseph P. Anderson, III/
Joseph P. Anderson, III
Registration No.: 59,245
BALLARD SPAHR LLP
Correspondence Customer Number: 23859

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Reflex USA LLC v. Longyear TM, Inc. and Globaltech Corporation Pty Ltd.

Electronic Patent Application Fee Transmittal

Application Number:	14692484
Filing Date:	21-Apr-2015
Title of Invention:	Core Barrel Head Assembly With An Integrated Sample Orientation Tool And System For Using Same
First Named Inventor/Applicant Name:	CHRISTOPHER L. DRENTH
Filer:	Joseph P. Anderson
Attorney Docket Number:	36362.0150U2-

Filed as Large Entity

Filing Fees for Utility under 35 USC 111(a)

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
Pages:				
Claims:				
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				
Extension-of-Time:				

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Miscellaneous:				
Submission- Information Disclosure Stmt	1806	1	180	180
		Total in USD ($)		**180**

Electronic Acknowledgement Receipt	
EFS ID:	30733431
Application Number:	14692484
International Application Number:	
Confirmation Number:	3851
Title of Invention:	Core Barrel Head Assembly With An Integrated Sample Orientation Tool And System For Using Same
First Named Inventor/Applicant Name:	CHRISTOPHER L. DRENTH
Customer Number:	23859
Filer:	Joseph P. Anderson
Filer Authorized By:	
Attorney Docket Number:	36362.0150U2-
Receipt Date:	23-OCT-2017
Filing Date:	21-APR-2015
Time Stamp:	16:58:27
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment Type	CARD
Payment was successfully received in RAM	$180
RAM confirmation Number	102417INTEFSW17041700
Deposit Account	
Authorized User	
The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows:	

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Foreign Reference	WO2006024111A1.pdf	1443623 449e5156260ef248bd5e6da5b5f75bcc842721bf	no	35
Warnings:					
Information:					
2	Foreign Reference	WO2007137356A1.pdf	1010681 03fb7ef1edb8d6b8566bff3782dce7c23b5ee706	no	27
Warnings:					
Information:					
3	Foreign Reference	WO2010094060A1.pdf	1676117 4cbfeacc54c94c5e528f5919e314611b5a862dc8	no	41
Warnings:					
Information:					
4	Foreign Reference	WO2013040641A1.pdf	3035235 c864715a13f7ede109777c67654f7d58dab702ca	no	65
Warnings:					
Information:					
5	Foreign Reference	WO2013126955A1.pdf	3837453 caa733e94a28eb05a738a73f2037fde4a4fe0242	no	82
Warnings:					
Information:					
6	Foreign Reference	WO2014089618A1.pdf	2294044 ac8489518f341f1e1af8611e97240432cd63cfcb	no	46
Warnings:					
Information:					

7	Non Patent Literature	Third_Party_Observation_8_17_2016.pdf	2204223 644e754b0297fc460b360ab3d86663ab590e0a54	no	42
Warnings:					
Information:					
8	Information Disclosure Statement (IDS) Form (SB08)	36362_0150U2_SIDS_SB08_10_23_2017.pdf	185375 bd75810e9966588e4d05fefe0aaa6a88961d8c77	no	2
Warnings:					
Information:					
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9	Transmittal Letter	36362_0150U2_SIDS_Transmittal_10_23_2017.pdf	120030 4aefc588983e3903e6658c510bebc824df44ecba	no	2
Warnings:					
Information:					
10	Fee Worksheet (SB06)	fee-info.pdf	30669 889749386b0ba4567c5c07d48a7eb37a922a44cb	no	2
Warnings:					
Information:					
		Total Files Size (in bytes):	15837450		

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New Applications Under 35 U.S.C. 111

If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
9 March 2006 (09.03.2006)

PCT

(10) International Publication Number
WO 2006/024111 A1

(51) International Patent Classification[7]: E21B 25/16, 47/024, 47/09

(21) International Application Number:
PCT/AU2005/001344

(22) International Filing Date:
5 September 2005 (05.09.2005)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
2004905021 3 September 2004 (03.09.2004) AU

(71) Applicant *(for all designated States except US)*: **AUSTRALIAN MUD COMPANY LTD** [AU/AU]; 5 Pitino Court, Osborne Park, Western Australia 6017 (AU).

(72) Inventor; and

(75) Inventor/Applicant *(for US only)*: **PARFITT, Richard** [GB/GB]; 3 Hyde Close, The Street, Kingston, Lewes East Sussex BN7 (GB).

(74) Agent: **WRAY & ASSOCIATES**; Level 4, The Quadrant, 1 William Street, Perth, Western Australia 6000 (AU).

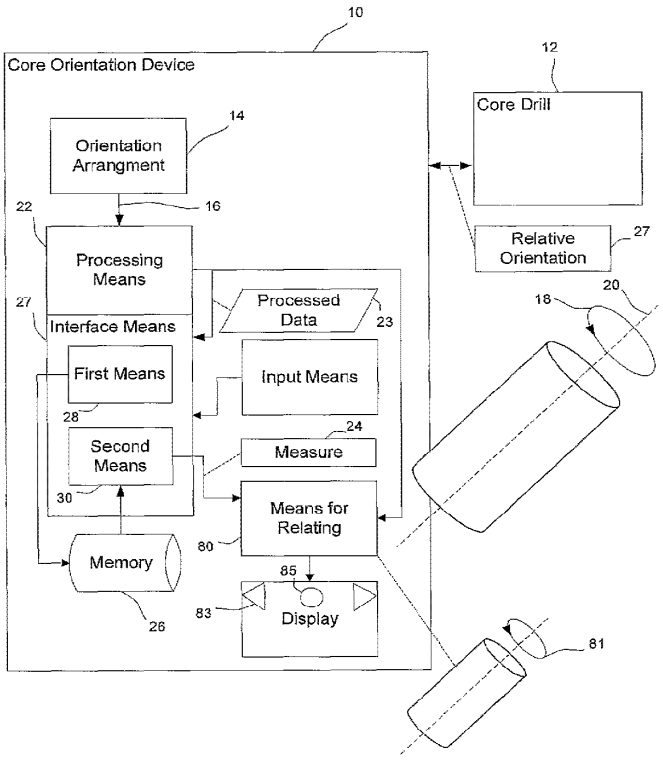
(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KP, KR, KZ, LC, LK,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

[Continued on next page]

(54) **Title:** CORE SAMPLE ORIENTATION



(57) **Abstract:** A core orientation device (10) for a core drill (12). The device (10) comprises an arrangement (14) for providing signals (16) associated with a physical orientation (18) of the core orientation device (10). Processing means (22) are provided for processing the signals (16) so as to provide processed data (23) from which a measure (24) of the physical orientation (18) of the core orientation device (10) can be established. The measure (24) is associated with the physical orientation (18) of the device (10) at a particular moment in time. A memory (26) is coupled to the processing means 22 for storing the processed data 23. To this end there is provided an interface means (27) comprising first means (28) for storing the processed data (23) in the memory (26) and second means (30) for accessing the memory (26) to provide the measure (24) of the physical orientation (18) of core orientation device (10) when required.

WO 2006/024111 A1

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.

"Core Sample Orientation"

Field of the Invention

This invention relates to core sample orientation. More particularly, the invention relates to an orientation device for providing an indication of the orientation of a core sample relative to a body of material from which the core has been extracted, and also to a method of core sample orientation identification.

Background Art

There is a need for core sampling in geological surveying operations.

Core samples are obtained through core drilling operations. Core drilling is typically conducted with a core drill comprising outer and inner tube assemblies. A cutting head is attached to the outer tube assembly, so that rotational torque applied to the outer tube assembly is transmitted to the cutting head. A core is generated during the drilling operation, with the core progressively extending along the inner tube assembly as drilling progresses. When a core sample is acquired, the core within the inner tube assembly is fractured. The inner tube assembly and the fractured core sample contained therein, are then retrieved from within the drill hole, typically by way of a retrieval cable lowered down the drill hole. Once the inner tube assembly has been brought to ground surface, the core sample can be removed and subjected to the necessary analysis.

Typically, the core drilling operation is performed at an angle to the vertical, and it is desirable for analysis purposes to have an indication of the orientation of the core sample relative to the ground from which it was extracted. It is therefore important that there be some means of identifying the orientation the core sample had within the ground prior to it having been brought to the surface.

Core orientation devices are used to provide an indication of the orientation of the core sample.

One common way of obtaining an indication of the orientation of a core sample is through use of an orientation spear comprising a marker (such as a crayon) projecting from one end of a thin steel shank, the other end of which is attached to a wire line.

The orientation spear is lowered down the drill hole, prior to the inner tube assembly being introduced. The marker on the orientation spear strikes the facing surface of material from which the core is to be generated, leaving a mark thereon. Because of gravity, the mark is on the lower side of the drill hole. The inner tube assembly is then introduced into the outer tube assembly in the drill hole. As drilling proceeds, a core sample is generated within the inner tube assembly. The core sample so generated carries the mark which was previously applied. Upon completion of the core drilling run and retrieval of the core sample, the mark provides an indication of the orientation of the core sample at the time it was in the ground.

There are also mechanical core orientation devices for marking a core sample prior to its extraction from the drill hole. Typically, mechanical devices are adapted to be incorporated in the inner tube assembly for marking the core. An example of such a mechanical orientation device is disclosed in WO 03/038212.

It is against this background and the problems and difficulties associated therewith that the present invention has been developed.

Disclosure of the Invention

According to a first aspect of the invention there is provided a core orientation device for a core drill, the device comprising: an arrangement for providing signals associated with a physical orientation of the core orientation device; processing means for processing the signals provided by the arrangement so as to provide processed data from which a measure of the physical orientation of the core orientation device can be established, the measure being associated with the physical orientation of the device at a particular moment in time; memory for storing the processed data; and interface means having first means for storing the

processed data in the memory and second means for accessing the memory to provide the measure of the physical orientation of core orientation device when required.

Most preferably the physical orientation of the core orientation device comprises a rotational orientation about an axis thereof. In these arrangements the rotational orientation is preferably about a longitudinal axis of the core orientation device. In other arrangements the physical orientation does not comprise a rotational orientation but rather comprises an angular orientation of the longitudinal axis above or below the horizontal plane. Embodiments may be proved where more than one orientation is measured. For example the physical orientation of the core orientation device may include both a rotational orientation about a longitudinal axis of the core orientation device and an angular orientation of the longitudinal axis above or below the horizontal plane.

Preferably the arrangement comprises triaxial accelerometer means. In these embodiments the triaxial accelerometer means may be advantageously housed by cushioning. The cushioning may increase in robustness outwardly. The cushioning may include an outer cushioning layer, an intermediate cushioning layer, and an inner cushioning layer which embraces the triaxial accelerometer means, with the robustness of cushioning progressively decreasing from the outer layer to the inner layer.

The triaxial accelerometer means may comprise three accelerometers arranged to determine acceleration in three orthogonal directions.

Preferably the core orientation device includes means for relating the measure of the orientation of the core orientation device with the present orientation thereof such that the core orientation device can be rotated to reflect the measure of the orientation of the core orientation device.

Preferably the core orientation device includes means for inputting the particular moment in time into the processing means and means for subsequently displaying the measure of the physical orientation of the device, the measure being

associated with the physical orientation of the device at the inputted moment in time.

Preferably the core orientation device has a body in the form of a housing having at least one threaded end for being engaged by an inner tube assembly of a core drill so as to form a part thereof. When engaged by the inner tube assembly the core orientation device preferably forms a length of the inner tube assembly.

Preferably the processing means includes a timer configured for ensuring that the processing means processes signals from the arrangement over predetermined time intervals.

Preferably the processor means includes integration means for integrating signals from the arrangement over a predetermined time interval.

Preferably the core orientation device includes means for displaying the commencement of a reference time.

According to a second aspect of the invention there is provided a core drill having a core orientation device comprising: an arrangement for providing signals associated with a rotational orientation of the core orientation device; processing means for processing the signals provided by the arrangement so as to provide processed data from which a measure of the rotational orientation of the core orientation device can be established, the measure being associated with the rotational orientation of the device at a particular moment in time; memory for storing the processed data; and interface means having first means for storing the processed data in the memory and second means for accessing the memory to provide the measure of the rotational orientation of core orientation device when required; wherein the core drill comprises: means for maintaining knowledge of the relative rotational orientation of a core drilled by the core drill and the core orientation device such that a measure of the rotational orientation of the core can be established using the measure of the rotational orientation of the core orientation device.

Preferably the means for maintaining knowledge of the relative rotational orientation of the core drilled by the core drill comprises a mechanism for preventing rotational movement about the length of the core sample, relative to the core orientation device.

Preferably the core orientation device includes means for relating the measure of the orientation of the core orientation device with the present orientation thereof such that the core orientation device can be rotated to reflect the measure of the orientation of the core orientation device.

Preferably the core drill includes an outer tube assembly and an inner tube assembly with the inner tube assembly having a means for accommodating the core orientation device along the length of the inner tube assembly. Preferably inner tube assembly includes a bearing allowing the means for accommodating the core orientation device to rotate relative to the outer tuber assembly but not relative to the core sample when the core is received by the inner tube assembly.

Preferably the outer tube assembly includes a spacer for allowing the inner tube assembly to be fitted with the outer tube assembly, when the core orientation device is accommodated. The core drill may accordingly comprise a retrofitted core drill.

Preferably the core orientation device is cylindrical and one end of the core orientation device includes display and input means. The display means preferably comprises and LCD display and the input preferably comprises a keypad. Most advantageously the end of the core orientation device is preferably protected by the inner tube assembly when accommodated.

According to a third aspect of the invention there is provided a method of obtaining and orientating a core sample comprising:

moving a core drill having a core orientation device from a first location to a drilling location and thereafter operating the core drill to drill a core sample;

generating signals associated with a physical orientation of the core orientation device between the first location and the drilling location;

processing the signals to provide processed data from which a measure of orientation of the core orientation device at the drilling location can be established; and

storing the processed data in memory such that the measure of the physical orientation of the core orientation device can be obtained therefrom.

Preferably the method includes maintaining knowledge of the relative physical orientation of the core orientation device and the core sample after the core sample has been drilled such that a measure of the orientation of the core sample taken by the core drill can be provided using the measure of the orientation of the core orientation device, when at a location spaced from the drilling location.

Preferably the method includes initialising the orientation of the core orientation device at the first location, said initialising being performed by commencing said generating and processing the signals at the first location with the core orientation device in a known orientation.

Preferably the location spaced from the drilling location is the first location and the measure of the orientation of the core orientation device is provided by maintaining the same relative orientation of the core orientation device and core sample after the core sample has been taken.

Preferably the method includes displaying a related measure of the orientation of the device and varying that measure upon rotation of the core sample and device such that a user can position the core sample and device in the measured orientation for marking.

In preferred embodiments of the invention the arrangement comprises three accelerometers operating on respective axes. The signals provided by the arrangement accordingly comprise acceleration signals which are associated with the physical orientation of the core orientation device. In these embodiments the processing means preferably processes the signals to provide data representative

of the change in orientation of the core orientation device over a plurality of predetermined time intervals. The interface means operates to store the changes in orientation in the memory.

By keeping track of the time taken to move the core drill to a core sample site and commence drilling, which may occur several kilometres below sea level, the operator, is preferably able to readily access the memory of the device, one raised to the surface, to provide a measure of the orientation of the core orientation device when aligned with the core sample, and thus thereby obtain a measure of the orientation of the core sample.

Dip in exploration drilling is an important measure in the geological analysis of core samples. Often dip is measured in degrees above or below the horizontal plane. Preferably the processing means processes the signals provided by the arrangement to provide processed data from which a measure of the orientation of the core orientation device relative to the horizontal plane can be established. Rotational orientation is also an important measure.

Preferably the processing means includes an analog to digital converter for converting the signals provided by the accelerometers.

Preferably core orientation device include a body that is adapted to be coupled to a tubular core drill for drilling the core sample. In these arrangements the processed data stored in the memory is preferably derived from signals associated with movement of the body of the core orientation device.

The processing means preferably includes timer means for determining predetermined intervals relative to a reference time, and means for storing the processed data in the memory upon each of the predetermined intervals terminating. Preferably the processor means includes mathematical integration means for use in processing the signals from the arrangement.

Preferably the core orientation device includes means for inputting a selected time interval and means for relating the selected time interval to at least a portion of the

processed data stored in the memory. Preferably the core orientation device includes means for using the portion of processed data to establish the measure of the orientation of the device, and means for displaying the measure to a user.

According to another aspect of the invention there is provided an orientation device for providing an indication of the orientation of a core sample relative to a body of material from which the core has been extracted, the orientation device comprising means for determining and storing the orientation of the device at predetermined time intervals relative to a reference time, means for inputting a selected time interval, means for relating the selected time interval to one of the predetermined time intervals and providing an indication of the orientation of the device at the selected time interval.

Such an orientation device is typically attached to an inner tube assembly of a core drill and is fixed against rotation relative thereto. For this purpose, the orientation device according to the invention preferably includes means for attachment to the inner tube assembly.

Preferably, the orientation device further includes means for comparing the orientation of the device at the selected time interval to the orientation of the device at any subsequent time and providing an indication of the direction in which the device should be rotated in order to bring it into an orientation corresponding to the orientation of the device at the selected time.

According to another aspect of the invention there is provided an orientation device for providing an indication of the orientation of a core sample relative to a body of material from which the core sample has been extracted, the orientation device comprising means for generating signals responsive to the orientation of the device, a processor for receiving the generated signals and for processing the signals to generate orientation data representative of the orientation of the device, means for storing the orientation data at predetermined time intervals, means for inputting a signal representative of a selected time interval to the processor, the processor operating to relate the selected time interval to the predetermined time

intervals and output a signal indicative of the orientation of the device at the selected time interval.

Preferably, further data is generated representative of the orientation of the device at any subsequent time and the processor is operable to output a signal to a display means to provide a visual indication of the direction in which the device should be rotated at said subsequent time in order to bring the device into an orientation corresponding to its orientation at the selected time.

According to yet another aspect of the invention there is provided a core drill comprising an inner tube assembly and an orientation device according to any one of the above aspects of the invention.

According to yet another aspect of the invention there is provided a core drill comprising an inner tube assembly and an orientation device according to the second aspect of the invention.

According to yet another aspect of the invention there is provided a method of providing an indication of the orientation of a core sample relative to a body of material from which the core sample has been extracted, the method comprising: drilling a core sample from a body of material with a core drill having an inner tube assembly; recording the orientation of the inner tube at predetermined time intervals with reference to an initial reference time during said drilling; recording the specific time interval beyond the reference time at which the core sample was separated from the body of material; removing the inner tube assembly and core sample contained therein from the body of material; and relating the recorded specific time to the recorded time intervals to obtain an indication of the orientation of the inner tube and consequently the core contained therein at the specific time interval.

Preferably, the method according to the invention is performed using an orientation device attached to the inner tube assembly, the orientation device being in accordance with an aspect of the invention.

Brief Description of the Drawings

The invention will be better understood by reference to the following description of one specific embodiment thereof as shown in the accompanying drawings in which:

Figure 1 is a schematic view of a core drill with an orientation device according to the embodiment;

Figure 2 is a schematic side elevational view of the arrangement shown in Figure 1;

Figure 3 is a further schematic side elevational view of a lower part of the arrangement shown in Figure 2;

Figure 4 is a schematic side elevational view in section of the orientation device;

Figure 5 is a block diagram illustrating various components of the orientation device; and

Figure 6 is a schematic plan view of a keypad and display provided at one end of the orientation device.

Best Mode(s) for Carrying Out the Invention

Referring to Figure 1 there is shown a core orientation device **10** for a core drill **12**. The device 10 comprises an arrangement **14** for providing signals **16** associated with a physical orientation of the core orientation device 10. According to the embodiment the physical orientation of the core orientation device 10 comprises rotational orientation **18** about a longitudinal axis **20** of the core orientation device 10.

The core orientation device 10 includes processing means **22** for processing the signals 16 provided by the arrangement 14 so as to provide processed data **23**

from which a measure **24** of the rotational orientation 18 of the core orientation device 10 can be established. The measure 24 is associated with the rotational orientation 18 of the device 10 at a particular moment in time.

A memory **26** is coupled to the processing means 22 for storing the processed data 23. To this end there is provided an interface means **27** comprising first means **28** for storing the processed data 23 processed by the processing means 22 in the memory 26 and second means **30** for accessing the memory 26 to provide the measure 24 of the rotational orientation 18 of core orientation device 10. This allows the measure 24 to be obtained when required.

As shown in Figure 2 the core drill **12** comprises an outer tube assembly **34** and an inner tube assembly **36** of generally conventional construction.

The orientation device 10 according to the embodiment is accommodated along the length **38** of the inner tube assembly 36, as shown in Figure 2 of the drawings. In this arrangement the inner tube assembly 36 comprises upper and lower parts **36a**, **36b** between which the orientation device 10 is fitted. The upper part 36a includes a bearing **40**, with the portion above the bearing 40 being rotatable with the outer tube assembly 34 and the portion below the bearing 40 being restrained against rotation because of frictional engagement with the core being generated. Thus, in this manner the bearing **40** allows the core orientation device 10 to rotate relative to the outer tube assembly 34 but not relative to the core sample when the core is received.

Incorporating the orientation device 10 in the inner tube assembly 36 increases the overall length of the inner tube assembly 36, a consequence of which is that the overall length of the outer tube assembly 34 needs to also be increased. A spacer **42** is provided in the outer tube assembly 34 for this purpose. Apart from modifications to the inner tube assembly 36 to accommodate the orientation tool 10, and also the spacer 42 provided in the outer tube assembly 36, the core drill 12 is of conventional construction and operates in a conventional way.

Referring to Figure 3 it can be seen that the inner tube assembly 36 comprises a back end assembly **33**, a replacement grease sub **35**, the core orientation device 10, 3m of inner tube **37** and core lifter case **39**.

As shown in Figure 4, the orientation device 10 comprises a housing **44** of generally cylindrical construction thereby defining the central longitudinal axis 20. The housing 44 has a generally cylindrical side wall **46** and two opposed ends **48**, **50**. The end 48 is open and internally threaded to provide a female threaded formation (not shown). A male threaded formation **52** is provided on the cylindrical side 46 of the housing 40 inwardly spaced from the other end 50.

The female threaded formation (not shown) and the male threaded formation 52 are provided so that the orientation device 10 can be installed between, and in threaded engagement with, the upper and lower parts 36a, 36b of the inner tube assembly 36, as shown in Figure 2. The inner tube assembly 36 accordingly has complementary threaded portions (not shown) which provide means for accommodating the core orientation device 10 along the length of the inner tube assembly 36.

The housing 44 accommodates an internal chassis **54**.

The chassis 54 has a cavity **56** which accommodates shock absorbing material **57** encasing a triaxial accelerometer means **58**.

The shock absorbing material 57 comprises several layers of cushioning. Specifically, there is an outer cushioning layer, an intermediate cushioning layer, and an inner cushioning layer which embraces the triaxial accelerometer means 58, with the robustness of cushioning progressively decreasing from the outer layer to the inner layer.

As shown in Figure 5, the housing 44 also accommodates a main printed circuit board **60** and an electrical power source **62** in the form of a lithium battery pack. The processing means 22 comprises an electronic circuit with chip on the main printed circuit board 60. The processing means 22 incorporates an analogue-to-

digital converter **64**, a low-power microcontroller **66** which provides a processor, a timer **68** and non-volatile memory **70**, as illustrated schematically in Figure 6. Thus in this embodiment the memory 26 forms part of the processing means 22.

The interface means 27 forms part of the processing means 22 while having the first means 28 for storing the processed data 23 and second means 30 for accessing the memory 26 to provide the measure 24 of the rotational orientation 18 of core orientation device 10 at the associated time. A watchdog circuit 71 is provided for watching the system. In instances where the device 10 shuts down downhole it can be reset at the surface.

The triaxial accelerometer means 58 comprises three internal silicon accelerometers operating along orthogonal directions X, Y and Z. The three accelerometers measure components of the earth's gravitational field.

Mathematically transforming the outputs from the three accelerometers allows the rotational orientation 18 of the device 10 about its longitudinal axis 20 to be determined.

More particularly, the signals 16 produced by the triaxial accelerometer means 43 are determinative of the change in orientation of the device 10 and are transmitted to the analogue-to-digital converter 64 which in turn transmits signals or signal data, to the microcontroller 66.

The timer 68 is provided for ensuring that the processing means processes signals from the arrangement over predetermined time intervals. In this arrangement the processor means 22 includes integration means for integrating signals over a particular predetermined time interval of 1 minute.

When orientation device 10 is operating, the relative orientation of the device is determined at regular intervals as determined by processing means 22. The processing means 22 employs the interface means 27 and second means 30 to store the processed data 23 in memory 26. In this embodiment, the time intervals at which the orientation is determined and stored comprises intervals of one

minute. In this way, there is a stored record of the orientation of the device 10 at minute intervals. The orientation of the orientation device 10 of course corresponds to the orientation of the lower part 36b of the inner tube assembly 36 which in turn corresponds to the orientation of a core sample progressively entering the inner tube assembly 36, as the lower part 36b does not rotate relative to the core sample.

The following process occurs in the operation of the core orientation device 10 and the core drill 12. A first step comprises moving the core drill 12 having the core orientation device 12 forming part thereof from a first location to a drilling location. After this the core drill 12 is operated to drill a core sample.

While the core drill is moved from the first location to the drilling location the core orientation device 10 generates acceleration signals 16 associated with the rotational orientation 18 of a core orientation device 10. The processing means 22 then processes the signals 16 to provide processed data 23 from which the measure 24 of rotational orientation 18 of the device 10 at the drilling location can be established. The processed data 23 is stored in memory 26 for later recall such that the measure 23 of the rotational orientation 18 of the device 10 can be obtained therefrom.

By using integration means and time intervals of one minute the processed data 23 is indicative of the change orientation of the device 10 in one minute intervals commencing from a reference time that corresponds to the time at which the orientation device 10 was started.

As shown in Figure 6, the core orientation device includes a membrane keypad **72** and an LCD display **74**, both of which are provided at end 50 of the orientation device 10. With this arrangement, the keypad 72 is accessible for operation from the end 50 and the display 74 is also visible from that end, but of course only when the orientation device 10 is not connected to upper part 36a of the inner tube assembly 36. The keypad 72 incorporates a window section **76** through which the LCD display 74 is visible. The keypad 72 has four keys in this embodiment, identified in Figure 4 as "N", "R", "+" and "-" keys.

As will be appreciated the membrane keypad 72 and 74 are protected by the inner tube assembly 36 when accommodated in the female threaded portion (not shown).

In this embodiment, the orientation device 10 is started by pressing the "N" key on the keypad 72. It is also necessary to record the time duration between starting the core orientation device 10 and extracting the core sample. Typically this is achieved by starting an external stop watch at the time of starting of the orientation device 10. Other arrangements are of course possible.

The stop watch is started at the time that the orientation device 10 displays a signal on the display 31 indicating that operation of the orientation device 10 has started. This provides for added accuracy.

Once the orientation device 10 has been started and recording of the subsequent time duration commenced, the inner tube assembly 36 is inserted into a drill hole for reception in the outer tube assembly 13, and the core drilling operation commenced. During the drilling operation, a core is progressively generated within the inner tube assembly, as previous explained.

When the core is to be extracted, the core drill operator refers to the timer and notes the time duration involved. Specifically, the operator either notes the full minute that has previously elapsed or waits until the next full minute elapses, and then records that time (as it must be recalled later). The operator then initiates the procedure for breaking the core from the body of material, ensuring that no rotation of the inner tube assembly 36 occurs. The inner tube assembly 36 is retrieved from the drill hole in the conventional manner.

At the surface, the upper part 36a of the inner tube assembly 36 is unscrewed from the orientation device 10, so as to the expose the end 50 thereof to provide access to the keypad 72 and display 74. As previously described the frictional engagement of the core and the inner tube assembly 36b along with bearing 40 allows the lower part 36b to rotate relative to the outer tube assembly 34 but not relative to the core sample.

As will be described the device 10 includes means **80** for relating the measure of the orientation of the core orientation device 10 with the current rotational orientation thereof. This allows for the core orientation device to consequently be rotated to reflect the measure of the orientation of the core orientation device. In this embodiment this is achieved by inputting the time duration as measured by the external stop watch into the the orientation device 10 through the keypad 72. This is done by pressing the "R" key to display numbers "00", and then pressing the +/- keys to display the relevant time duration in minutes.

Once the time has been entered, the key "R" is pressed once. This causes the means 80 for relating the core orientation device to the current rotational orientation thereof, to determine a current rotational orientation **81** from processing means 22 and display a graphical indication **83** of the direction in which the orientation device 10 and the lower part 36b of the inner tube assembly 36 attached thereto should be rotated. Rotating the device and lower part 36b in this direction causes the core contained within the inner tube assembly 36b to move into an orientation corresponding to its orientation at the time that it was in the ground before extraction. At this time a symbol **85** is displayed to alert the operator.

Once the required orientation has been established, the core sample within the inner tube assembly 36 can be marked as necessary. After removal of the core sample from the lower part 36b of the inner tube assembly 36, the upper part 36a can be fitted onto the orientation device 10 and the inner tube assembly 36 used for the next core sample drilling stage.

The process by which the orientation device 10 determines and provides a graphical indication of the direction in which it should be rotated, together with the lower part 15b of the inner tube assembly 36 attached thereto, in order to be at an orientation corresponding to the orientation of the core sample in its original position within the ground, operates on the following basis. The time measurement measured by the operator and entered into the keypad 72 represents the duration of time between starting the orientation device 10 and the point at which the particular drilling process was terminated in order to fracture the

core sample from the body of material to which it is attached so that the core sample could be retrieved from the drill hole and brought to surface level.

As previously explained, the orientation of the orientation device 10 is determined at predetermined intervals, which are minute intervals in this embodiment. The timer simply allows identification of the particular minute interval at which the appropriate orientation reading was taken and recorded.

Inputting the time measurement into the keypad 72 allows the controller 66 to compare the inputted reading to the various stored readings and identify the relevant orientation reading. The triaxial accelerometer means 58 provides signals responsive to the orientation of the orientation device 10 at any instant in time, including when operating at surface level. Such signals allow the controller 66 to process the signals and determine the orientation of the device at any instant. The controller 53 can compare the instant of the device at surface level at any instant in time to the particular recorded reading corresponding to the orientation of the device at the time that the core sample was separated from the body of material to which it was previously attached. This comparison is processed to provide data which is outputted to the display 74 to provide a visual indication of the direction in which the orientation device should be rotated, as previously explained.

In this embodiment, the visual indication comprises a directional arrow arrangement showing the required rotational direction. Once the orientation device 10 is at the required orientation, the display 74 provides an image 85 representing that condition.

From the forgoing, it is evident that the present invention provides an orientation device which does not require physical marking of a core sample prior to extraction thereof from the ground. Indeed, the orientation device according to the embodiment is particularly convenient for an operator to use. All that is required is for the operator to start the orientation device prior to the inner tube assembly 36 being inserted into the drill hole, and contemporaneously start a

timer for recording the time duration before the drilling operation ceases to allow the generated core sample to be retrieved.

Modifications and improvements may be made without departing from the scope of the invention. For example in other embodiment the physical orientation does not comprise a rotational orientation but rather a measure of degrees above or below the horizontal plane.

Throughout the specification, unless the context requires otherwise, the word "comprise" or variations such as "comprises" or "comprising", will be understood to imply the inclusion of a stated integer or group of integers but not the exclusion of any other integer or group of integers.

The Claims Defining the Invention are as Follows

1. A core orientation device for a core drill, the device comprising: an arrangement for providing signals associated with a physical orientation of the core orientation device; processing means for processing the signals provided by the arrangement so as to provide processed data from which a measure of the physical orientation of the core orientation device can be established, the measure being associated with the physical orientation of the device at a particular moment in time; memory for storing the processed data; and interface means having first means for storing the processed data in the memory and second means for accessing the memory to provide the measure of the physical orientation of core orientation device when required.

2. A core orientation device as claimed in claim 1 wherein the physical orientation of the core orientation device comprises a rotational orientation about a longitudinal axis of the core orientation device.

3. A core orientation device as claimed in claim 1 or 2 wherein the physical orientation of the core orientation device comprises an angular orientation of the longitudinal axis above or below the horizontal plane.

4. A core orientation device as claimed any one of claims 1 to 3 wherein the arrangement for providing signals comprises triaxial accelerometer means.

5. A core orientation device as claimed any one of claims 1 to 4 wherein the core orientation device includes means for relating the measure of the orientation of the core orientation device with the present orientation thereof such that the core orientation device can be rotated to reflect the measure of the orientation of the core orientation device.

6. A core orientation device as claimed any one of claims 1 to 5 wherein the core orientation device includes input means for inputting the particular moment in time into the processing means and display means for subsequently

displaying the measure of the physical orientation of the device, the measure being associated with the inputted moment in time.

7. A core orientation device as claimed in claim 6 wherein the core orientation device is cylindrical and one end of the core orientation device includes the display and input means in the form of a LCD display and keypad.

8. A core orientation device as claimed any one of claims 1 to 7 wherein the core orientation device has a body in the form of a housing having at least one threaded end for being engaged by an inner tube assembly of the core drill.

9. A core orientation device as claimed in claim 8 wherein, when engaged by the inner tub assembly, the core orientation device forms a length of the inner tube assembly.

10. A core orientation device as claimed any one of claims 1 to 9 wherein the processing means includes a timer configured for ensuring that the processing means processes signals from the arrangement over predetermined time intervals.

11. A core orientation device as claimed any one of claims 1 to 10 wherein the processor means includes integration means for integrating signals from the arrangement over a predetermined time interval.

12. A core orientation device as claimed any one of claims 1 to 11 wherein the processor means includes timer means for determining predetermined intervals relative to a reference time, and means for storing the processed data in the memory upon each of the predetermined intervals terminating.

13. A core drill having a core orientation device comprising: an arrangement for providing signals associated with a rotational orientation of the core orientation device; processing means for processing the signals provided by the arrangement so as to provide processed data from which a measure of the rotational orientation of the core orientation device can be established, the

measure being associated with the rotational orientation of the device at a particular moment in time; memory for storing the processed data; and interface means having first means for storing the processed data in the memory and second means for accessing the memory to provide the measure of the rotational orientation of core orientation device when required; wherein the core drill comprises: means for maintaining knowledge of the relative rotational orientation of a core drilled by the core drill and the core orientation device such that a measure of the rotational orientation of the core can be established using the measure of the rotational orientation of the core orientation device.

14. A core drill as claimed in claim 13 wherein the means for maintaining knowledge of the relative rotational orientation of the core drilled by the core drill comprises a mechanism for preventing rotational movement about the length of the core sample, relative to the core orientation device.

15. A core drill as claimed in claim 13 or 14 including means for relating the measure of the orientation of the core orientation device with the present orientation thereof such that the core orientation device can be rotated to reflect the measure of the orientation of the core orientation device.

16. A core drill as claimed in any one of claims 13 to 15 wherein the core drill includes an outer tube assembly and an inner tube assembly with the inner tube assembly having a means for accommodating the core orientation device along the length of the inner tube assembly.

17. A core drill as claimed in claim 16 wherein the inner tube assembly includes a bearing allowing the means for accommodating the core orientation device to rotate relative to the outer tuber assembly but not relative to the core sample when the core is received by the inner tube assembly.

18. A core drill as claimed in claim 16 or 17 wherein the core orientation device is cylindrical and one end of the core orientation device includes display and input means in the form of a LCD display and keypad, the end of the core

orientation device being protected by the inner tube assembly when accommodated.

19. A core drill as claimed in any one of claims 16 to 18 wherein the outer tube assembly includes a spacer for allowing the inner tube assembly to be fitted with the outer tube assembly when the core orientation device is accommodated.

20. According to a third aspect of the invention there is provided a method of obtaining and orientating a core sample comprising:

moving a core drill having a core orientation device from a first location to a drilling location and thereafter operating the core drill to drill a core sample;

generating signals associated with a physical orientation of the core orientation device between the first location and the drilling location;

processing the signals to provide processed data from which a measure of orientation of the core orientation device at the drilling location can be established; and

storing the processed data in memory such that the measure of the physical orientation of the core orientation device can be obtained therefrom.

21. A method as claimed in claim 20 wherein the method includes maintaining knowledge of the relative physical orientation of the core orientation device and the core sample after the core sample has been drilled such that a measure of the orientation of the core sample taken by the core drill can be provided using the measure of the orientation of the core orientation device when at a location spaced from the drilling location.

22. A method as claimed in claim 20 or 21 wherein the method includes initialising the orientation of the core orientation device at the first location, said initialising being performed by commencing said generating and processing the signals at the first location with the core orientation device in a known orientation.

23. A method as claimed in any one of claims 20 to 22 wherein the method includes displaying a related measure of the orientation of the device and varying that measure upon rotation of the core sample and device such that a user can position the core sample and device in the measured orientation for marking.

24. An orientation device for providing an indication of the orientation of a core sample relative to a body of material from which the core has been extracted, the orientation device comprising means for determining and storing the orientation of the device at predetermined time intervals relative to a reference time, means for inputting a selected time interval, means for relating the selected time interval to one of the predetermined time intervals and providing an indication of the orientation of the device at the selected time interval.

25. An orientation device as claimed in claim 24 attached to an inner tube assembly of a core drill and fixed against rotation relative thereto, the orientation device including means for attachment to the inner tube assembly.

26. An orientation device as claimed in claim 24 or 25 including means for comparing the orientation of the device at the selected time interval to the orientation of the device at any subsequent time and providing an indication of the direction in which the device should be rotated in order to bring it into an orientation corresponding to the orientation of the device at the selected time.

27. An orientation device for providing an indication of the orientation of a core sample relative to a body of material from which the core sample has been extracted, the orientation device comprising means for generating signals responsive to the orientation of the device, a processor for receiving the generated signals and for processing the signals to generate orientation data representative of the orientation of the device, means for storing the orientation data at predetermined time intervals, means for inputting a signal representative of a selected time interval to the processor, the processor operating to relate the selected time interval to the predetermined time

intervals and output a signal indicative of the orientation of the device at the selected time interval.

28. An orientation device as claimed in claim 27 wherein data is generated representative of the orientation of the device at any subsequent time and the processor is operable to output a signal to a display means to provide a visual indication of the direction in which the device should be rotated at said subsequent time in order to bring the device into an orientation corresponding to its orientation at the selected time.

29. A core drill comprising an inner tube assembly and an orientation device according to claim 24.

30. A core drill comprising an inner tube assembly and an orientation device according to the claim 27.

31. A method of providing an indication of the orientation of a core sample relative to a body of material from which the core sample has been extracted, the method comprising: drilling a core sample from a body of material with a core drill having an inner tube assembly; recording the orientation of the inner tube at predetermined time intervals with reference to an initial reference time during said drilling; recording the specific time interval beyond the reference time at which the core sample was separated from the body of material; removing the inner tube assembly and core sample contained therein from the body of material; and relating the recorded specific time to the recorded time intervals to obtain an indication of the orientation of the inner tube and consequently the core contained therein at the specific time interval.

32. A device substantially as herein described with reference to the accompanying drawings.

33. A method substantially as herein described with reference to the accompanying drawings.

Figure 1

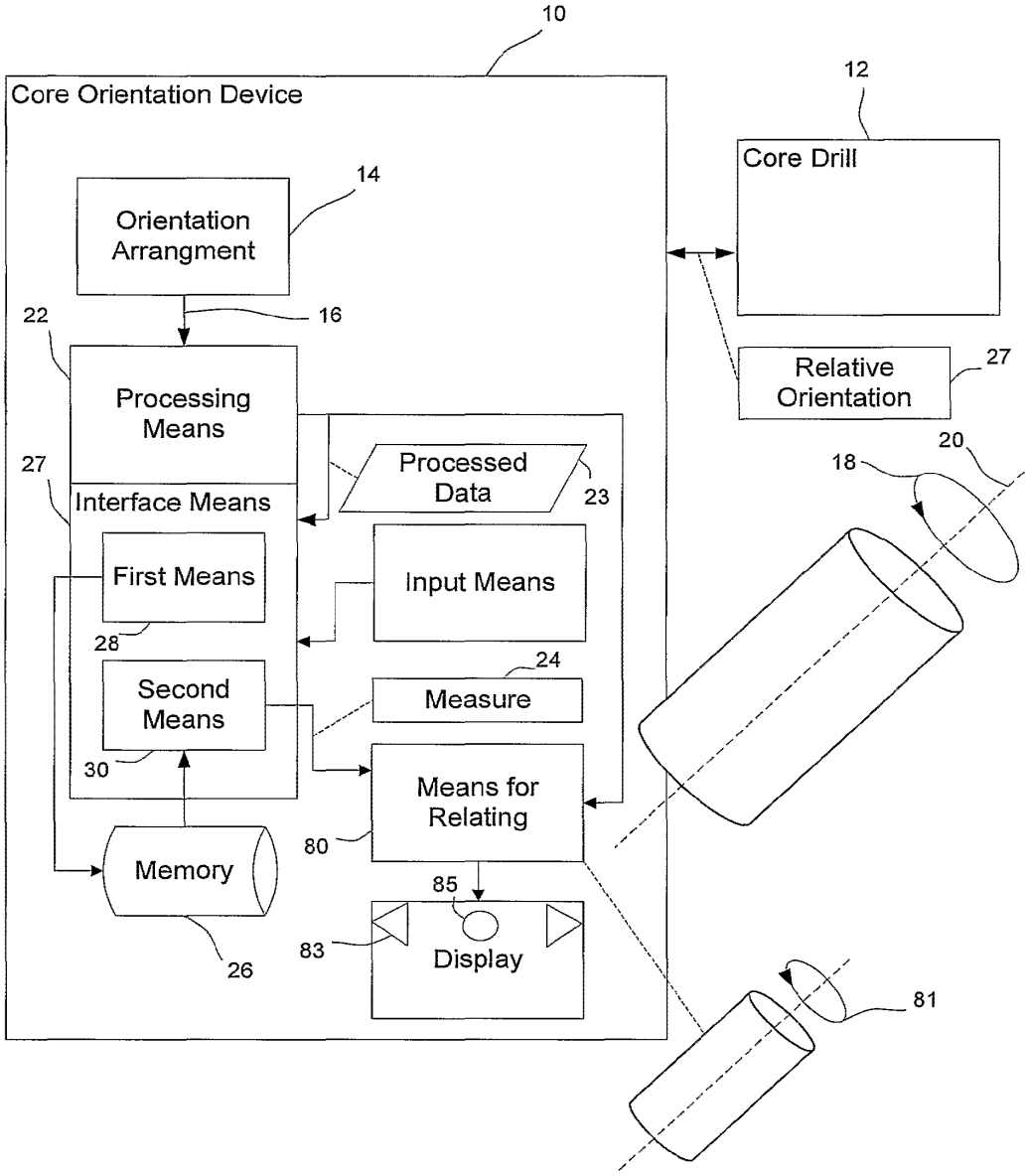

10
Core Orientation Device
12
Core Drill
14
Orientation Arrangment
16
22
Processing Means
27
Relative Orientation
27
Interface Means
Processed Data
23
18
20
First Means
28
Input Means
24
Second Means
Measure
30
Means for Relating
80
Memory
85
83
Display
26
81

Figure 2

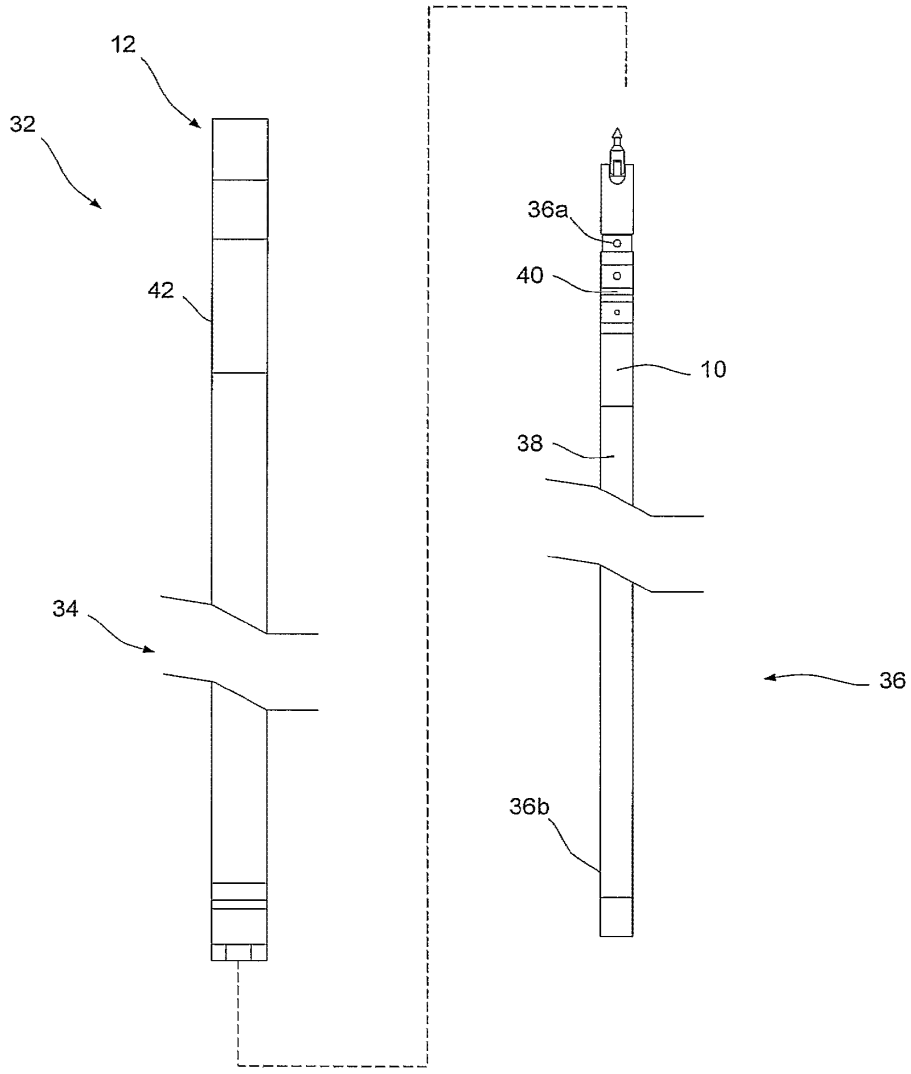


Figure 3

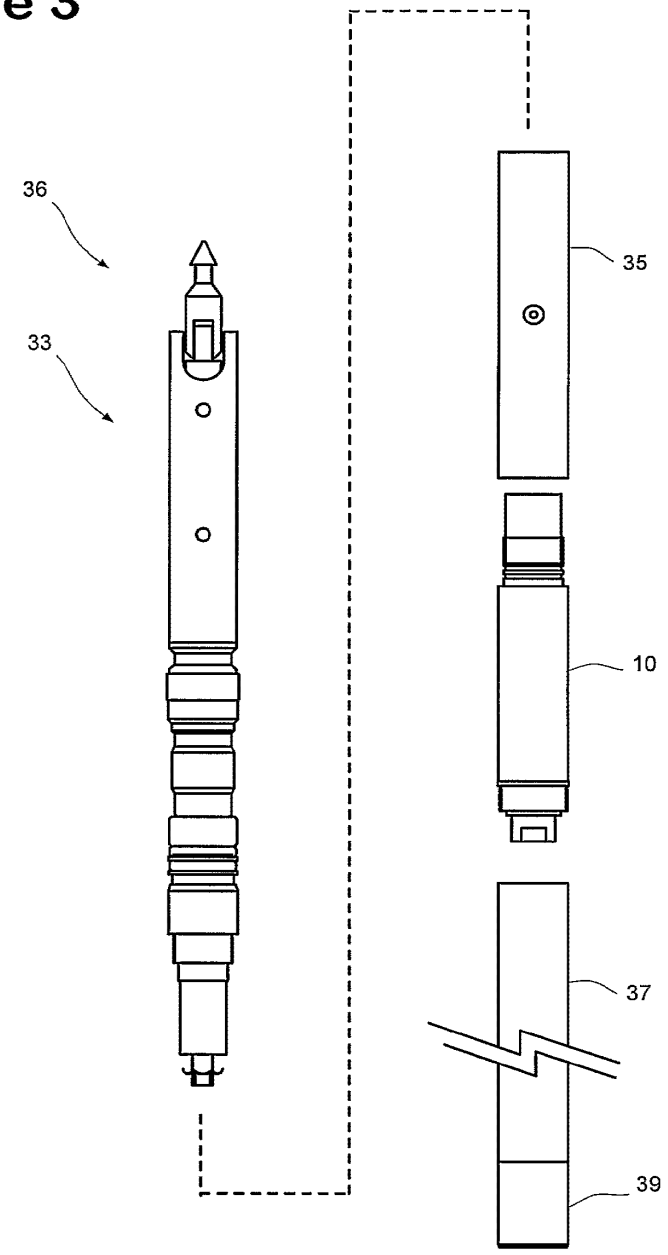


Figure 4

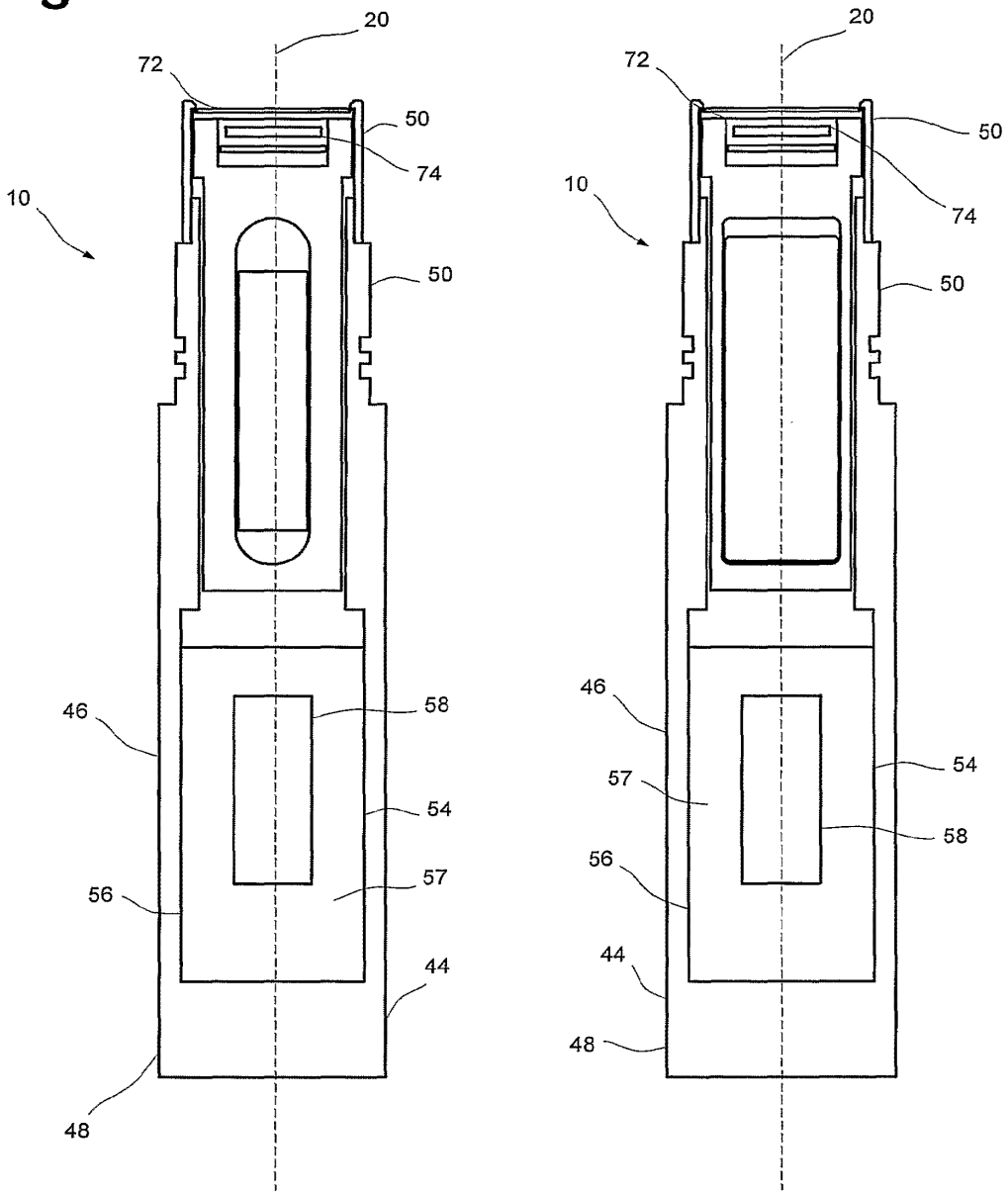

20
72
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Figure 5

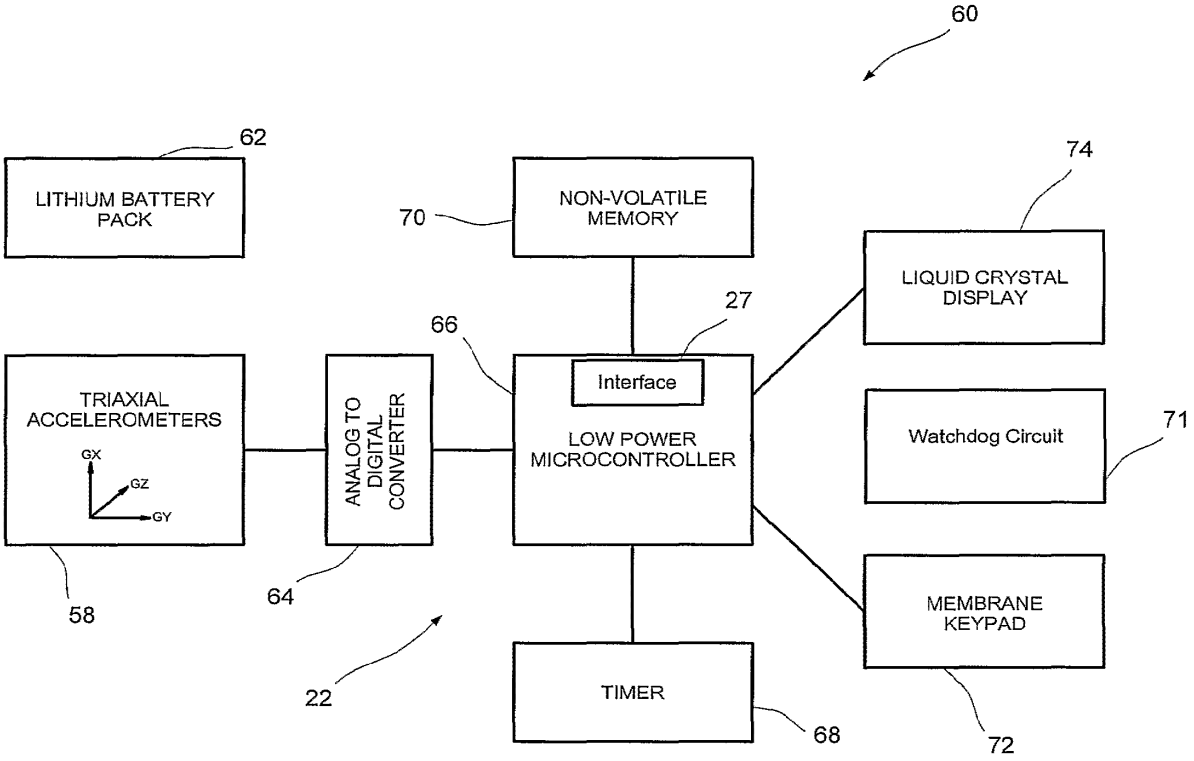
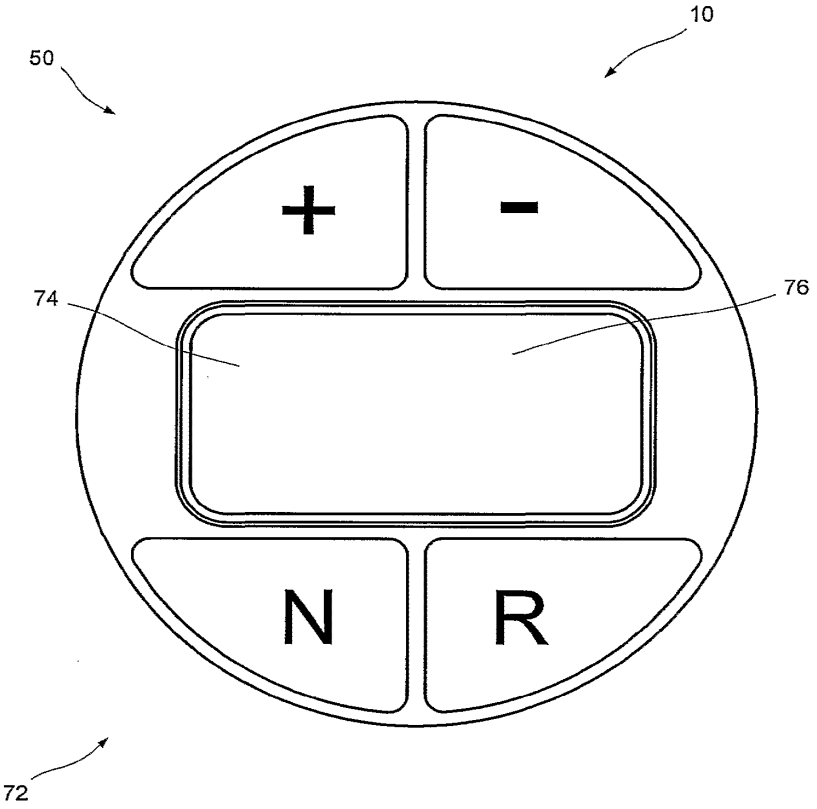

60
62
LITHIUM BATTERY PACK
70
NON-VOLATILE MEMORY
74
LIQUID CRYSTAL DISPLAY
27
66
Interface
LOW POWER MICROCONTROLLER
TRIAXIAL ACCELEROMETERS
GX
GZ
GY
ANALOG TO DIGITAL CONVERTER
Watchdog Circuit
71
MEMBRANE KEYPAD
58
64
22
TIMER
68
72

Figure 6



INTERNATIONAL SEARCH REPORT

International application No.
PCT/AU2005/001344

A. CLASSIFICATION OF SUBJECT MATTER

Int. Cl. [7]: E21B 25/16, 47/024, 47/09

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)

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

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
DWPI : IPC as above, E21B 49/IC, and keywords [(core+ and (orient or direction)), signal+, process+, stor+, data, memory, generat+, measur+, time, interval, reference, select+, record+, indicat+ and like terms)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
P, X	CA 2456506 A1 (SCOTT) 3 January 2005 See whole document	
A	US 5105894 A (ENDERLIN) 21 April 1992	
A	Derwent Abstract Accession No 2001-180537/18, Class H01, RU 2160821 C2 (PILOT RES PRODN ENTERP) 20 December 2000	

☐ 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	Date of mailing of the international search report
16 November 2005	24 NOV 2005
Name and mailing address of the ISA/AU AUSTRALIAN PATENT OFFICE PO BOX 200, WODEN ACT 2606, AUSTRALIA E-mail address: pct@ipaustralia.gov.au Facsimile No. (02) 6285 3929	Authorized officer **S. GHOSH** Telephone No : (02) 6283 2163

INTERNATIONAL SEARCH REPORT

International application No.
PCT/AU2005/001344

Supplemental Box
(To be used when the space in any of Boxes I to VIII is not sufficient)

Continuation of Box No: III

The international application does not comply with the requirements of unity of invention because it does not relate to one invention or to a group of inventions so linked as to form a single general inventive concept. In coming to this conclusion the International Searching Authority has found that there are different inventions as follows :

1. Claims 1 to 23 are directed to a core drill having a core orientation device, the core orientation device for the core drill and a method of obtaining and orientating a core sample. It is considered that an arrangement for providing signals associated with a physical orientation of the core orientation device, processing means for processing the signals to establish a measure of the physical orientation of the core orientation device at a particular moment in time, means for storing data and means to provide the measure of the physical orientation of the core orientation device when required comprises a first "special technical feature".

2. Claims 24 to 31 are directed to an orientation device and a method for providing an indication of the orientation of a core sample relative to a body of material from which the core sample has been extracted. It is considered that means for determining and storing the orientation of the device at predetermined time intervals relative to a reference time, means for inputting a selected time interval, means for relating the selected time interval to one of the predetermined time intervals and providing an indication of the orientation device at the selected time interval comprises a second "special technical feature".

Since the abovementioned groups of claims do not share any of the technical features identified, a "technical relationship" between the inventions, as defined in PCT rule 13.2 does not exist. Accordingly the international application does not relate to one invention or to a single inventive concept, **a priori**.

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.
PCT/AU2005/001344

This Annex lists the known "A" publication level patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent Document Cited in Search Report	Patent Family Member
CA 2456506	
US 5105894	

Due to data integration issues this family listing may not include 10 digit Australian applications filed since May 2001.

END OF ANNEX

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
6 December 2007 (06.12.2007)

PCT

(10) International Publication Number
WO 2007/137356 A1

(51) International Patent Classification:
E21B 25/16 (2006.01) *E21B 47/09* (2006.01)

(21) International Application Number:
PCT/AU2007/000752

(22) International Filing Date: 29 May 2007 (29.05.2007)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
2006902873 29 May 2006 (29.05.2006) AU

(71) Applicant *(for all designated States except US)*: **2IC AUSTRALIA PTY LTD** [AU/AU]; Unit 2, 10 McElligott Court, Canning Vale, Western Australia 6155 (AU).

(72) Inventors; and
(75) Inventors/Applicants *(for US only)*: **BEACH, Andrew** [AU/AU]; 380 Crossman Road, Boddington, Western Australia 6390 (AU). **MCLEOD, Gavin** [AU/AU]; 19 Blaven Way, Ardross, WA 6153 (AU).

(74) Agent: **GRIFFITH HACK**; Level 19, 109 St Georges Tce, Perth, Western Australia 6000 (AU).

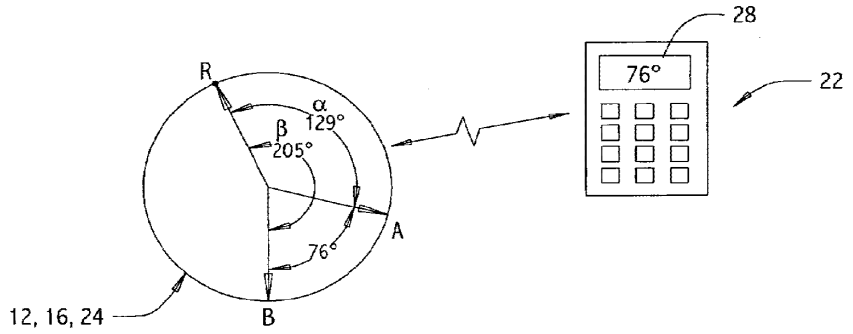
(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, 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: CORE ORIENTATION SYSTEM



(57) Abstract: A core orientation system (10) comprises an electronic orientation device (12) that connects to a back end (14) of a core tube (16), a core position indicator (CPI) 18 adapted for engagement with the core tube (16) when on the ground, and a remote control unit 22 that communicates between the device (12) and the CPI (18). The device (12) electronically logs orientation data of a reference point R on the core tube 16 relative to a first datum A at a time when a core sample (24) contained in the core tube (16) is in an insitu orientation. Once the core tube is retrieved and placed in a stable position the device (12) again logs orientation data of the reference point R to a second datum B. A rotational displacement θ from the first datum A to the second datum B is calculated and transferred to the CPI (18) which is then moved about the core tube (16). When the CPI (18) is moved to a position where it is rotated by θ from the second datum B, it emits a signal to indicate the position of the first datum A.

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CORE ORIENTATION SYSTEM

Field of the Invention

The present invention relates to a core orientation system for a core sample extracted from the ground.

Background of the Invention

Core sampling is used to allow geological surveying of the ground for various purposes including exploration and/or mine development. Analysis of the material within the core sample provides information on the composition of the ground. However in order to accurately interpret the information obtained from the core sample it is necessary to have knowledge of the orientation of the core sample relative to the ground from which it was extracted.

There are many known devices for orientating a core sample. Some of these devices are attached to a front end of a core tube and physically mark, or take an impression of a face of, the core sample. By relating the marking or impression to a known reference one is then able to determine the orientation of the core sample.

Other systems are known that electronically record information or data relating to the core orientation at the commencement or end of a core run rather than physically mark or take impressions of the core sample. One known system utilises an electronic orientation device that is screwed onto a back end of the core tube, a stop-watch, and a marking jig. A drill rig operator having attached the device to a core tube arms the device immediately prior to lowering the core tube through an associated drill string of a core drill and simultaneously commences a stop-watch. The device records readings of core orientation at fixed time intervals. On completion

of drilling and prior to the breaking of the core, the stop-watch is stopped by the drill rig operator. The core tube is then retrieved from the ground and placed in a stable position. The time appearing on the stop-watch is then entered on the device. The device internally retrieves the related orientation data corresponding to that time. The entire core tube is then rotated on the jig until a visual indication is given by the device that the core is lying at an orientation with the underside of the core sample representing the bottom of the hole. A jig may then be used to assist a person in physically marking the core, for example with a pencil to denote the location of the bottom of the hole.

Summary of the Invention

According to one aspect of the present invention there is provided a core orientation system comprising:

an electronic orientation device configured for connection with a core tube and which logs data relating to the orientation of a core sample extracted from the ground via the core tube;

a core position indicator configured for demountable engagement with the core tube;

a remote control unit that communicates with both the electronic orientation device and the core position indicator to transfer the data from the electronic orientation device to the core position indicator; and,

a signalling system that emits a sensory signal when the core position indicator is moved about the core tube to a position which based on the data is indicative of the ground in situ orientation of the core.

In various embodiments the signalling system may be incorporated in either the remote control unit or in the core position indicator. The sensory signal may comprise

any one or more of the group comprising: an auditory signal, a visible signal, a tactile signal.

The core position indicator may comprise a guide for guiding a marking implement for marking the core and/or the core tube or a component of the core tube. It is envisaged that the component of the core tube that may be marked is a core lifter case coupled to a front end of the core tube.

The guide may comprise a straight edge or a slot to facilitate the guiding of the marking implement to scribe or otherwise mark an indicia on or along a portion of the core and/or the core tube or a component thereof at a location indicative of the orientation of the core relative to the predetermined reference. Typically the predetermined reference corresponds with either the bottom or the top of a hole from which the core is extracted referenced to gravity.

The guide may further comprise a sensor to detect when the marker was moved along the guide and check that the guide was at the correct orientation at the time of marking. If the guide was not in the correct orientation the signalling system could indicate the error to the operator to enable them to correct the alignment or the angular displacement could be recorded and included in a downloadable data record for the geologist or core logging staff to enable them to correct the alignment.

The guide may in addition or alternatively comprise a recess or hole positioned to receive the marking implement at a location where the implement can be guided to contact a radial end face of the core sample.

The core position indicator may further comprise a mount that engages the core tube to couple the core position

indicator to the core tube in a manner allowing the core position indicator to rotate about the core tube. Further, the mount may further facilitate the sliding of the core position indicator axially of the core tube.

Both the core position indicator and the remote control unit may comprise a means of storing a downloadable data record of one or more data readings to provide a permanent record for auditing purposes.

According to a further aspect of the present invention there is provided a method of indicating the orientation of a core sample extracted from the ground comprising:

electronically logging orientation data of a reference point on core tube relative to a first datum at a time when a core sample contained in the core tube is in its in situ orientation relative to the first datum;

retrieving the core tube and placing the core tube in a stable position;

electronically logging orientation data of the reference point on core tube relative to a second datum when the core sample is in the stable position

determining a rotational displacement θ of first datum relative to the second datum

mounting a core position indicator on the core tube;

electronically transferring the displacement θ to the core position indicator;

moving the core position indicator about the core tube; and

emitting a sensory signal when the core position indicator is rotated to a position displaced by θ from the second datum and thus pointing to or otherwise indicating the position of the first datum on the core sample.

The reference datum may comprise a bearing with reference to gravity.

Brief Description of the Drawings

An embodiment of the present invention will now be described by way of example only with reference to the accompanying drawings in which:

Figure 1 is a schematic representation of a core orientation system in accordance with an embodiment of the present invention;
Figure 2 is an enlarged view of a portion of the system in Figure 1 in which an end of a core sample partially extends from an associated core tube;
Figure 3 is an enlarged view of a portion of the system in Figure 1 in which an end of a core sample is disposed inside of the core tube;
Figure 4 is a schematic representation of a core sample orientated by an embodiment of the present invention; and,
Figures 5 - 8 represent sequentially the steps in recording positional data of the core tube and core sample and transferring that data to the core sample.

Detailed Description of Preferred Embodiment

As illustrated in the accompanying drawings and in particular, in Figure 1, an embodiment of the core orientation system 10 in accordance with the present invention comprises an electronic orientation device 12 adapted for connection with a back end 14 of a core tube 16, a core position indicator (CPI) 18 adapted for demountable engagement with a front end 20 of the core tube 16, and a remote control unit 22 that communicates with both the electronic core orientation device 12 and the core position indicator 18. The system 10 further includes a signalling system (not separately shown) that emits a sensory signal. The signalling system may be incorporated in the CPI 18 although it may also reside

within or be a part of the remote control unit 22. In yet a further variation both of the CPI 18 and the remote control unit 22 can include and/or function as signalling systems to emit the same or different sensory signals.

The electronic orientation device 12 logs orientation data of the core tube 16. Assuming there is either no, or a known or measurable, rotational slippage between the core tube 16 and the in situ core sample 24 orientation is the same as or related to the orientation of the core tube 16. Once drilling for the core 24 has ceased, and the core sample has been broken from the ground and retrieved to the surface with the core tube 16, the CPI 18 is demountably coupled to the front end 20 and the remote control unit 22 is operated to communicate with both the orientation device 12 and the CPI 18 to transfer data relating to the *in situ* orientation of the core sample 24 from the orientation device 12 to the CPI 18. The CPI 18 is then moved about the front end 20 to a position where it points to, is in alignment with, or otherwise indicates the orientation of the core 24 relative to a predetermined reference.

Looking at the system 10 in more detail, the electronic orientation device 12 may take the form of any known electronic orientation device used for downhole logging but which is further modified by the provision of a transceiver circuit to enable wireless communication between the device 12 and the remote control unit 22. Both the remote control unit 22 and the device 12 include internal timers that are synchronised when the unit 22 is used to initiate the device 12. Thus, prior to lowering the core tube 16 through a drill string an operator pushes an appropriate button on the remote control unit 22 which initiates or activates the orientation device 12 and simultaneously synchronises the timers in both devices.

The orientation device may be pre-programmed, or programmable via the remote control unit 22, to take orientation readings at predetermined time intervals. For example orientation readings may be taken every 1, 2 or 5 seconds. In a further embodiment multiple successive readings may be taken over a small time interval or pulse and repeated over a longer duty cycle.

The orientation device 12 takes readings or measurements of orientation as the core tube 12 descends through the core drill and is latched into place near a downhole end of the core drill. The core drill is operated to cut a core sample 24 from the ground. Once the drill rig operator has ceased drilling and just before or after lifting of the drill string to effect a core break the operator pushes a "take reading" button 26 on the remote control unit 22. The control unit 22 records the time elapsed since the device 12 was initiated. In one variation, the device 12 may take multiple readings (eg say 3 readings) over a predetermined recording period, for example 30 seconds. During this period the unit 22 may be programmed to display a message such as "please wait" and/or diplay a count down of the recording period. This provides time for stabilisation of the core drill and core tube 12 and also provides a degree of error checking in that if the three readings are shown as being disparate by more than a allowable tolerance then it may be deduced that the reading is faulty and should be disregarded.

More particularly, in terms of error checking the data logged by the orientation device 12 may be analysed, either by the device 12 itself while in the hole, or by the remote control unit 22, or indeed by a separate device, using statistical measures of its accuracy. The logged data may be analysed to identify the presence of any movement during the logging of orientation data. This may include linear and/or rotational direction of motion,

which is itself logged and provided to a user. These self checks may be beneficial to identify service requirements. In particular the indication of movement during logging may be beneficial in identifying improper operation of the orientation device and thus flag the need for training or retraining of operators. For example multiple logged orientation data on either side, in a time line sense, of a specific individual or averaged data point used as the orientation data at the time of core break, can be analysed to ascertain whether there was any appreciable motion (ie change in logged orientation) immediately before or after the core break when the core orientation data was being logged. Thus data in a time period adjacent of a core break (and in particular before the core break) can be analysed to detect linear/rotational motion of the core tube 12. If this motion is outside of an acceptable range the system 10 can log that information and the signaling system can emit a sensory signal to alert a user of that variation.

The operator can be signalled of the expiration of the recording period by the unit 22 displaying a message such as "reading complete retrieve core tube" and/or an auditory message.

The drill operator may then retrieve the core tube 16 with the orientation device 12 in a conventional manner and place the core tube in a stable position such as on a core rack or other surface.

At this time the CPI 18 is coupled to the front end 20 of the core tube 16. To this end the CPI 18 is provided with a mount 30 in the form of a spring clip 30 that snaps on to the tube 16. The mount 30 enables the CPI 18 to be rotated or turned relative to the core tube 16, about a longitudinal axis of the tube 16 as well as being able to slide axially relative the tube 16.

The CPI 18 includes an electronics module 32 which contains transceiver circuits to enable wireless communication with the remote control unit 22; and electronic orientation circuit which senses the orientation of the CPI 18 relative to a known reference (typically gravity). It is further envisaged that the electronics module 32 would include the signalling system.

The CPI 18 further comprises a guide 34 for guiding a marking implement such as a pencil, pen or scribing instrument for marking the core 24 or the core tube 16, or a component thereof such as a core lifter case 36 that is screwed to the front end 20 of the core tube 16. The guide 34 is in the form of a thin straight slat 37 that extends in a direction of the axis of the core tube 16 and is provided with an elongate slot 38. A forward most end of the slat 37 is also provided with a guide block 40 provided with an axially extending hole 42. The CPI 18 is coupled to the tube 16 in a position so that the block 40 overhangs a front end of the core lifter case 36 and more particularly, as shown in Figure 2, is in a location in front of a face 44 of core sample 24 contained within the core tube 16.

Figures 5 - 8 depict the process in logging orientation data of the core sample 24, transferring that data to the CPI 18, and subsequently moving the CPI 18 relative to the core tube 16 to a location where the CPI 18 points to or otherwise indicates or signifies the ground in situ location of the core sample 24.

Figure 5 represents the initial state of the system 10 prior to lowering the core tube 16 into a bore hole through a drill string (not shown). The orientation device 12 is turned ON and an internal timer within the orientation device 12 is synchronised with an internal

timer of the remote control unit 22. This is achieved by wireless communication between the remote control unit 22 and a transceiver within the orientation device 12.

As mentioned above, while the core tube 12 descends through the drill string and bore hole the orientation device 12 regularly logs data relating to the position of the core tube 12. Moreover, the logging of data provides positional information of the location of a reference point R relative to a predetermined first reference datum. The reference point R is an arbitrary but fixed reference point designated by the orientation device 12. It is possible but not necessary for the reference point R to have a corresponding physical marking on the exterior of the device 12. In this embodiment the first reference datum is a zero bearing relative to the direction of gravity or a "gravity vector", marked as A in Figures 6 - 8.

Just prior to or after breaking of the core sample 24 from the in situ ground, an operator presses the "take reading" button 26 on the remote control unit 22. This activates the timer within the control unit 22 to log the period of time between initiation of the orientation device 12, and the time just before or after core break. This time maybe displayed on a display 28, and in this example is shown as 57 minutes. The core tube 16 with its core 24, is retrieved from the drill string and bore hole and placed in a stable position such as on a core or rod rack. An operator now presses a "sync reading" button 46 on the remote control unit 22. This causes the remote control unit 22 to interrogate the orientation device 12 and retrieve the orientation data of the core tube 16 and core 24 at the time corresponding to when the "take reading" button 26 was pressed. In the example shown in Figure 6, the orientation of the reference point R from the reference datum A 57 minutes after the initiation of the

orientation device 12 is shown as α. That is at the time just before or after the core break the reference point R was at a bearing of α from the "gravity vector" A..

The reference point A represents the lower most point in the bore hole from which the core sample 24 is extracted and thus corresponds with the lowest point or line of the core sample 24 when in situ in the ground. When the core tube 16 is retrieved and placed on the core rack, it is possible, although unlikely, that point A will correspond with the position of the gravity vector B at ground level (i.e. a zero bearing with reference to the direction of gravity),which can be considered to be a fresh or second reference datum. Thus, the remote control unit 22 is operated to interrogate the orientation device 12 to obtain a fresh or second reading of the displacement or bearing β of the reference point R from the second datum being the current "gravity vector" position B. The unit 22 can now calculate the displacement of the downhole gravity vector position A to the current gravity vector position B as $\theta=\beta-\alpha$ .Once the remote control unit 22 has obtained the angle θ from the device 12, the control unit 22 transfers this data to the CPI 18. For example if α is measured as 129° , and β as 205 then the angle θ in this example will be 76° and displayed on the display 28 of the remote control unit 22. It should be understood however that there is no requirement for this displacement to be shown on the display 28.

As shown in Figure 8, the CPI 18 is now mounted on the core tube 16 and juxtaposed so that the guide block 40 overhangs the core lifter case 36 and is in front of the face 44 of the core 24. Most conveniently, but not essentially, the CPI 18 is mounted on the core tube 16 at a location about 180° form the gravity vector reference location B. In any event as previously described the CPI 18 has an electronic circuit to sense its own bearing

relative to the gravity vector bearing. The unit 22 transfers the angle θ to the CPI 18. The unit 22 may optionally also receive the instantaneous bearing of the CPI 18. The CPI knowing both θ and its own orientation, both referenced to gravity vector B, can calculate the rotational displacement required to reach the downhole gravity vector position A. Assuming the CPI 18 is initially placed exactly 180 from B, then in the current example the CPI (and indeed the unit 22) can calculate that the CPI requires a rotation of 104° in the clockwise direction to reach point A. If the unit 22 is operated to interrogate the CPI 18 as the CPI 18 is being rotated about the core tube, the unit 22 can also display or otherwise provide information as to the required rotation (i.e. in terms of degrees and direction) for the CPI 18 to reach the position A. For example the display 28 can display a message such as "rotate right" or "rotate left" or "stop" when the position A is reached. Further either one or both of the CPI 18 and unit 22 can provide graded sensory signals that vary as the CPI 18 gets closer to or further from the position A. The sensory signals may include for example visual signals such as the turning ON of a light or the flashing of a light on one or both of the CPI 18 and the control unit 22; emission of an auditory signal by one or both of the CPI 18 and the remote control unit 22; the display of a visual readable message on the remote control unit 22 or the emission of a tactile signal such as a vibration from the remote control unit 22.

The initial mounting of the CPI 18 on the core tube 16 is depicted by the phantom line in Figure 8 while the position of the CPI 18 when rotated to position B is shown in the solid line

CPI 18, now points to or otherwise indicates the location of the reference datum A which corresponds with the lower

most point of a core tube 16 and thus the core 24 at the time of the core break. This then characterises the location of the core sample 24. A user can mark one or both of the core 24 and core lifter case 36 by running a marker along the slot 38 to produce a "bottom of the hole line" 48 on the core sample 24. In the event that the core sample 24 is jammed in the core lifter case 36 as shown in Figure 4, the line 48 is initially marked along a core lifter case 36. The core lifter case 36 can then be unscrewed from the remainder of the core tube. As the core lifter case 36 is rotated the core sample 24 rotates with it thereby maintaining its rotational position relative to the core lifter case 36. The line 48 can then be extended on the core sample 24 once it is removed from the core tube 16. The face 44 of the core sample 24 can also be marked with a marker to produce a dot 50 (shown in Figure 4) by passing the marker through the hole 42 formed in the guide block 40. Dot 50 again represents the location of the bottom or lowest point in the hole from which the core sample 24 was extracted.

The CPI 18 may further comprise a sensor to detect when the marker was moved along the guide 34 and/or inserted in the hole 42 and check that the CPI 18 was at the correct orientation at the time of marking. This can be effected for example by way of bobbin slidably retained in the slot 38 and into which a marker in inserted to mark the underlying core tube 16 and core sample 24, with say a magnetic sensor mounted in the slat 37 to detect motion of the bobbin; or for the hole 42 by say an optical sensor that can detect the insertion of a marker in the hole 42. The CPI 18 can be programmed or otherwise configured to detect when such motion occurs. Indeed the CPI 18 may be further programmed to automatically send its orientation to the remote control unit 22 whenever the marking process is sensed. If the CPI 18 was not in the correct orientation (i.e. pointing to the datum A) at that time

the signalling system (whether embedded in the CPI 18 or in the remote control unit 22) will indicate an error to the operator to enable them to correct the alignment or the angular displacement from the correct could be recorded and included in a downloadable data record for the geologist or core logging staff to enable them to correct the alignment.

It is further envisaged that various embodiments of the orientation device 12 may perform other self checks and provide users with status information/messages. Status messages may include one or a combination of: low battery power, communications error, system faults.

Either one or both of the CPI 18 and the remote control unit 22 may also be configured to store and allow downloading of records of one or more data readings to provide a permanent record for auditing purposes. This can easily facilitated by incorporation of an electronic memory or allocation of an area of existing electronic memory in the CPI 18 and remote control unit 22, with download being via the existing communications system that operates between the CPI 18 and remote control unit or via a hardware connection such as a USB jack.

Modifications and variations in the above described embodiments that would be obvious to a person of ordinary skill in the art are deemed to be within the scope of the present invention the nature of which is to be determined from the above description.

Claims:

1. A core orientation system comprising:

an electronic orientation device configured for connection with a core tube and which logs data relating to the orientation of a core sample extracted from the ground via the core tube;

a core position indicator configured for demountable engagement with the core tube;

a remote control unit that communicates with both the electronic orientation device and the core position indicator to transfer the data from the electronic orientation device to the core position indicator; and,

a signalling system that emits a sensory signal when the core position indicator is moved about the core tube to a position which based on the data is indicative of the ground in situ orientation of the core.

2. The core orientation system according to claim 1 wherein the signalling system is incorporated in any one or both of the remote control unit or in the core position indicator.

3. The core orientation system according to claim 1 or 2 wherein the sensory signal comprises any one or more of the group comprising: an auditory signal, a visible signal, a tactile signal.

4. The core orientation system according to any one of claims 1 - 3 wherein the core position indicator comprises a guide for guiding a marking implement for marking the core and/or the core tube or a component of the core tube.

5. The core orientation system according to claim 4 wherein the component comprises a core lifter case coupled to a front end of the core tube.

6. The core orientation system according to claim 4 or 5 wherein the guide comprises a straight edge or a slot to facilitate the guiding of the marking implement to scribe or otherwise mark an indicia on or along a portion of the core and/or the core tube or a component thereof at a location indicative of the orientation of the core relative to the predetermined reference.

7. The core orientation system according to claim 6 wherein the predetermined reference corresponds with either the bottom or the top of a hole from which the core is extracted referenced to gravity.

8. The core orientation system according to any one of claims 4 - 7 wherein the guide comprises a recess or hole positioned to receive the marking implement at a location where the implement can be guided to contact a radial end face of the core sample.

9. The core orientation system according to any one of claims 1 - 8 wherein the core position system indicator comprises a mount that engages the core tube to couple the core position indicator to the core tube in a manner allowing the core position indicator to rotate about the core tube.

10. The core orientation system according to claim 9 wherein the mount further facilitates the sliding of the core position indicator axially of the core tube.

11. The core orientation system according to any one of claims 1 - 10 wherein the remote control unit and the electronic orientation device each comprise a respective timer and wherein the remote control unit is operable to synchronise the timers.

12. The core orientation system according to claim 11 wherein the electronic orientation device logs orientation data at time intervals measured by its timer.

13. The core orientation system according to claim 11 or 12 wherein the remote control unit is operated to record a period of time between synchronisation of the timers and a time just before or after lifting of a drill in which the core tube is disposed to effect a core break detaching the core sample from the ground.

14. The core orientation system according to any one of claims 1 - 13 wherein the core position indicator comprises an electronic orientation circuit for sensing rotational orientation of the core position indicator relative to a known second reference datum.

15. The core orientation system according to any one of claims 1-14 wherein one or both of the core position indicator and the remote control unit comprise a memory for storing a downloadable record of the data.

16. The core orientation system according to any one of claims 4-15 wherein the guide further comprises a sensor to detect when the marking implement is used to mark the core and/or the core tube or a component of the core tube and wherein the core position system performs a test to check that the guide was at the correct orientation at the time of marking.

17. The core orientation system according to claim 16 wherein signalling system emits a sensory signal in the event that the guide was not in the correct orientation at the time of marking.

18. The core orientation system according to claim 17 wherein, in the event that the guide was not in the correct orientation at the time of marking the core

position system records an angular displacement from the correct orientation.

19. The core orientation system according to any one of claims 1 - 18 wherein the core orientation system is configured to analyse multiple data logged in a period of time in the vicinity of a time at which a core break action is preformed to detect and/or record variations in motion of the core tube in the period of time.

20. The core orientation system according to claim 19 wherein the signalling system emits a sensory signal in the event that the variation in motion is outside of a predetermined range of motion.

21. A method of indicating the orientation of a core sample extracted from the ground comprising:

electronically logging orientation data of a reference point on core tube relative to a first datum at a time when a core sample contained in the core tube is in its in situ orientation relative to the first datum;

retrieving the core tube and placing the core tube in a stable position;

electronically logging orientation data of the reference point on core tube relative to a second datum when the core sample is in the stable position

determining a rotational displacement θ of first datum relative to the second datum

mounting a core position indicator on the core tube;

electronically transferring the displacement θ to the core position indicator;

moving the core position indicator about the core tube; and

emitting a sensory signal when the core position indicator is rotated to a position displaced by θ from the second datum and thus pointing to or otherwise indicating the position of the first datum on the core sample.

FIGURE 1

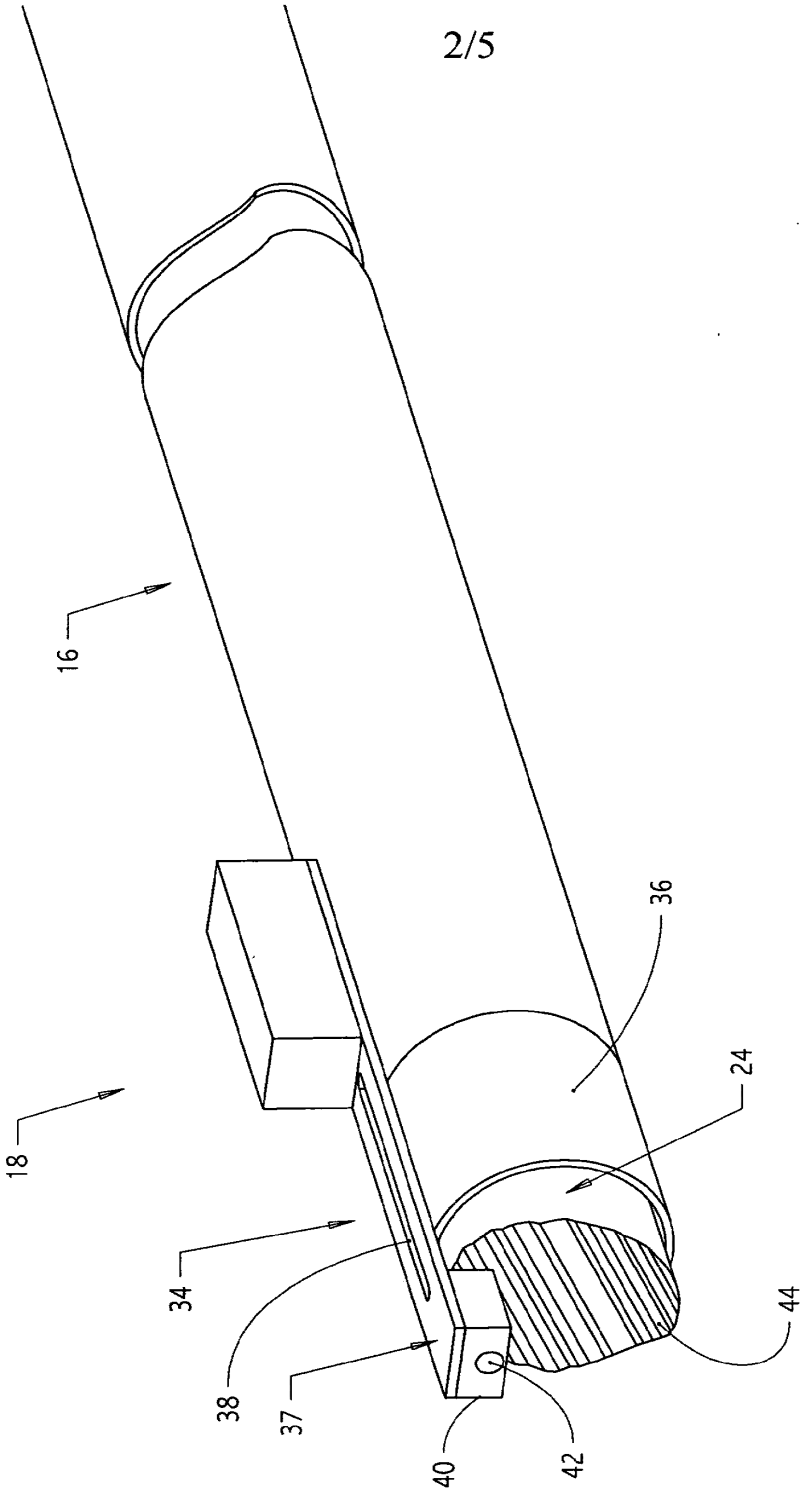


FIGURE 2

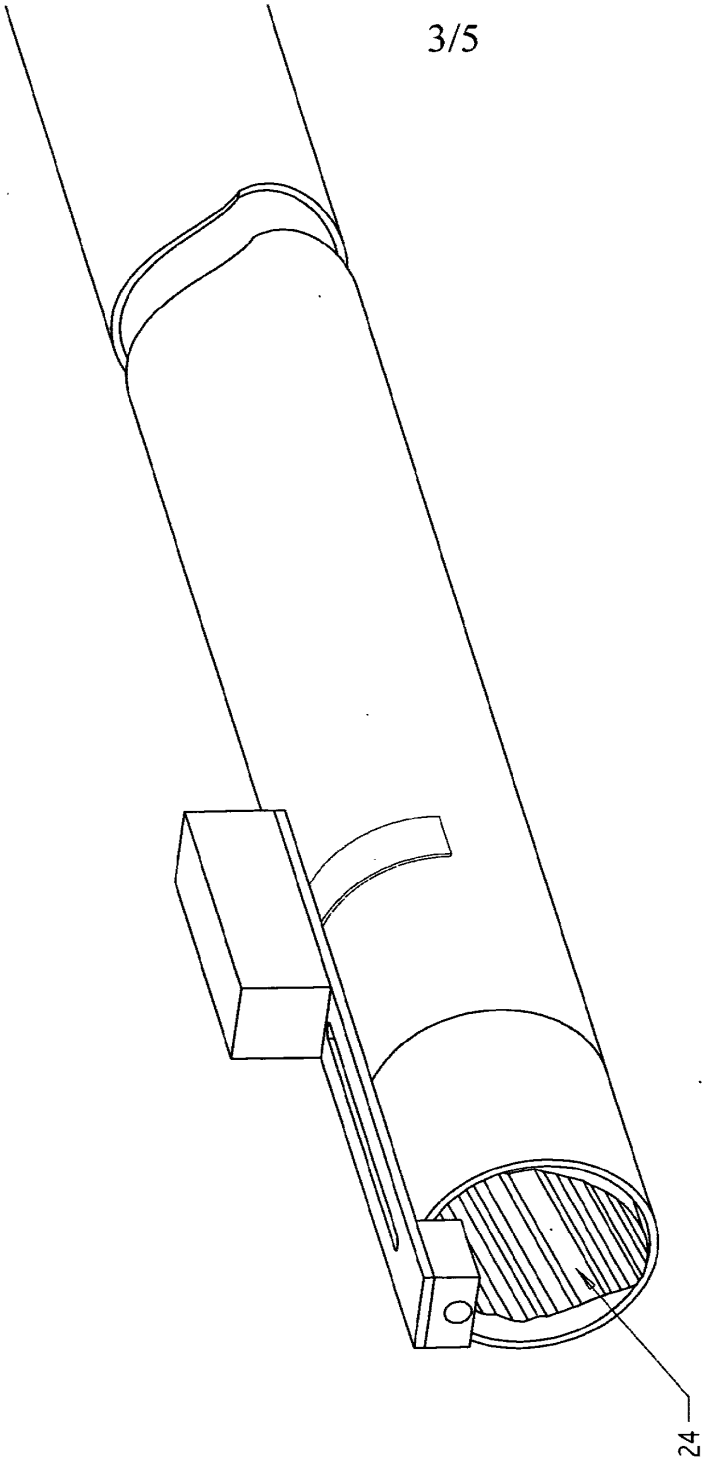


FIGURE 3

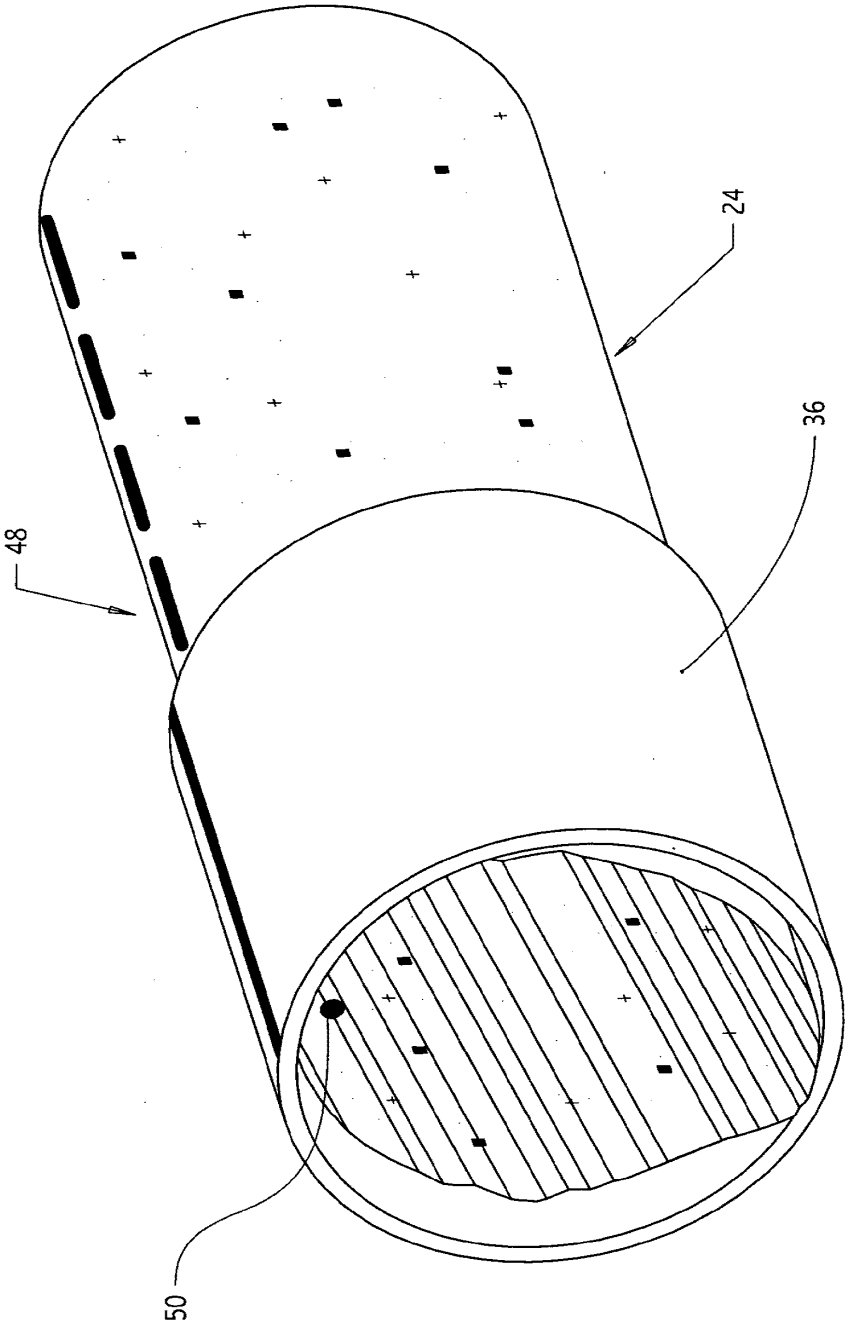


FIGURE 4

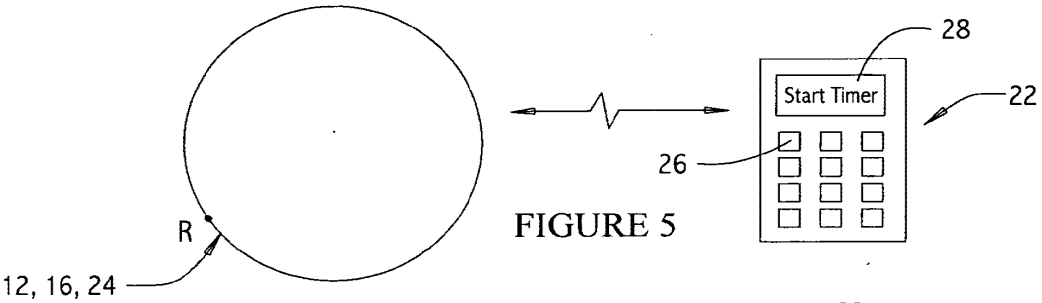


FIGURE 5

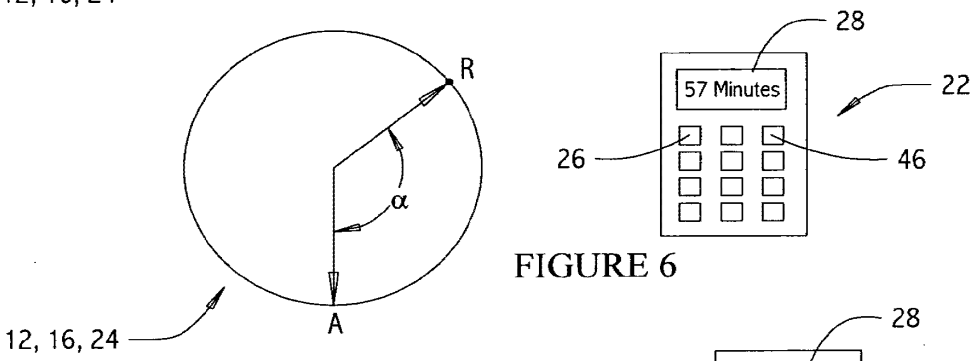


FIGURE 6

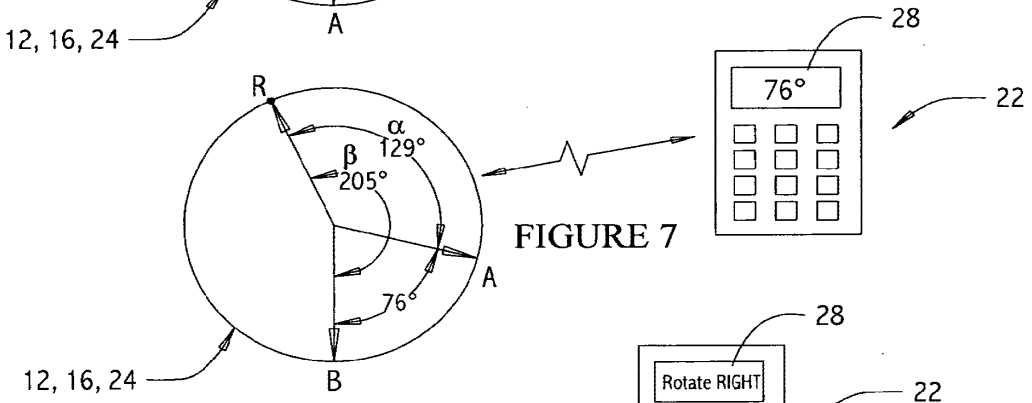


FIGURE 7

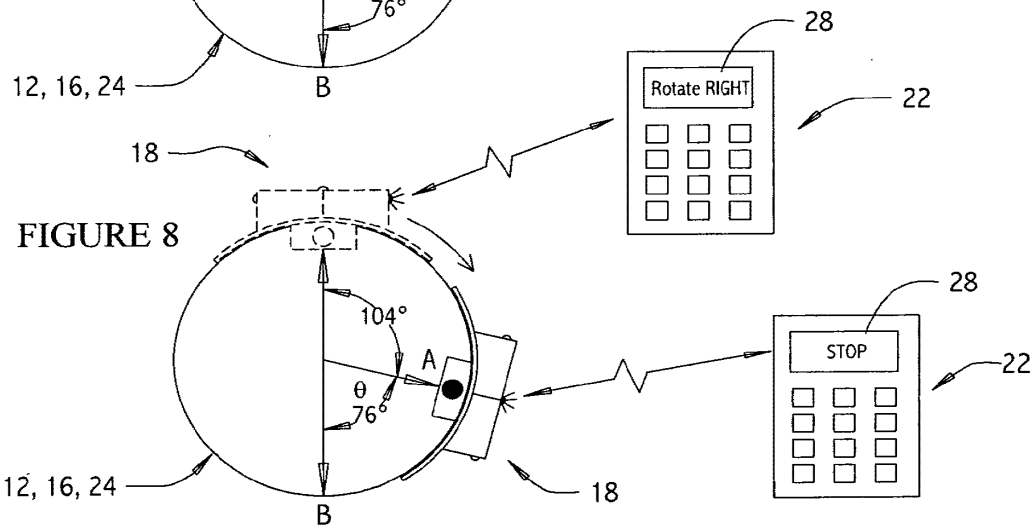


FIGURE 8

INTERNATIONAL SEARCH REPORT

International application No.
PCT/AU2007/000752

A. CLASSIFICATION OF SUBJECT MATTER

Int. Cl.

E21B 25/16 (2006.01) ***E21B 47/09*** (2006.01)

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)

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

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
Dwpi: E21B 25/16, 47/024, 47/09, 39/00, 49/ic with keywords

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
	WO 2006/024111 A1 (AUSTRALIAN MUD COMPANY LTD) 9 March 2006	
X	The whole document	1-3, 11-15, 19 and 20
Y		4-8
	CA 2456506 A1 (SCOTT) 3 January 2005	
X	The whole document	1-3, 11-15, 19 and 20
Y		4-8
	US 6659196 B1 (ANDERSON) 9 December 2003	
Y	The whole document	4-8
	US 4311201 A (STEWART et al) 19 January 1982	
Y	The whole document	4-8

[X] Further documents are listed in the continuation of Box C [X] 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

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"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	Date of mailing of the international search report
06 August 2007	8 - AUG 2007
Name and mailing address of the ISA/AU AUSTRALIAN PATENT OFFICE PO BOX 200, WODEN ACT 2606, AUSTRALIA E-mail address: pct@ipaustralia.gov.au Facsimile No. (02) 6285 3929	Authorized officer **LEOPOLD FILIPOVIC** AUSTRALIAN PATENT OFFICE (ISO 9001 Quality Certified Service) Telephone No : (02) 6283 2105

Form PCT/ISA/210 (second sheet) (April 2007)

INTERNATIONAL SEARCH REPORT	International application No. PCT/AU2007/000752

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	Derwent Abstract Accession No. 97-242837/22, Class X25, (NIPON SHINKO KK) 25 March 1997	1-20
A	US 2005/0199393 A1 (GOLDBERG et al) 15 September 2005 The whole document	1-20

Form PCT/ISA/210 (continuation of second sheet) (April 2007)

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.
PCT/AU2007/000752

This Annex lists the known "A" publication level patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent Document Cited in Search Report		Patent Family Member					
WO	2006024111	AU	2005256104	AU	2006100113	CA	2559030
CA	2456506						
US	6659196	AU	49004/00	CA	2294409	CA	2378748
		EP	1198657	GB	2370589	WO	0075480
		ZA	200110321				
US	4311201						
JP	9078975						
US	2005199393	US	7168508	US	2007107939		

Due to data integration issues this family listing may not include 10 digit Australian applications filed since May 2001.

END OF ANNEX

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
26 August 2010 (26.08.2010)

PCT

(10) International Publication Number
WO 2010/094060 A1

(51) International Patent Classification:
E21B 25/16 (2006.01) *E21B 47/024* (2006.01)

(21) International Application Number:
PCT/AU2010/000165

(22) International Filing Date:
16 February 2010 (16.02.2010)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
2009900670 17 February 2009 (17.02.2009) AU

(71) Applicant *(for all designated States except US)*: **IMDEX TECHNOLOGY AUSTRALIA PTY LTD** [AU/AU]; 5 Pitino Court, Osborne Park, Western Australia 6017 (AU).

(72) Inventor; and
(75) Inventor/Applicant *(for US only)*: **PARFITT, Richard John** [GB/GB]; 3 Hyde Close, The Street, Kingston, Lewes Sussex BN7 3PA (GB).

(74) Agent: **WRAYS**; Ground Floor, 56 Ord Street, West Perth, Western Australia 6005 (AU).

(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ, CA, CH, CL, 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, PE, PG, PH, PL, PT, RO, RS, RU, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, 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, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:
— *with international search report (Art. 21(3))*
— *with amended claims (Art. 19(1))*

WO 2010/094060 A1

(54) **Title**: MODULAR CORE ORIENTATION SYSTEM

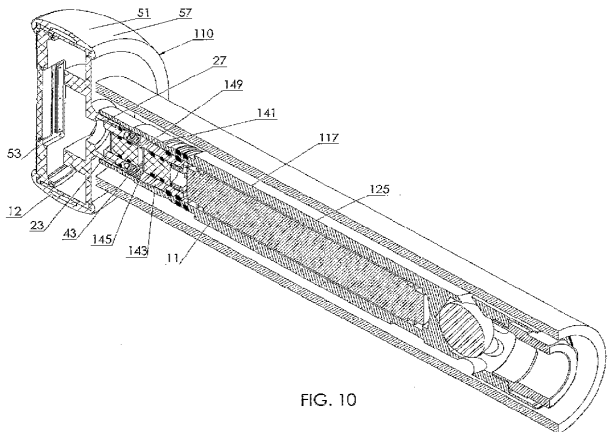


FIG. 10

(57) **Abstract**: A core sample orientation system (10) comprising a first portion (11) and a second portion (12). The first portion (11) comprises a downhole unit adapted to be connected to a core tube of a core drill, and the second portion (12) comprises a control unit. The downhole unit (11) is adapted for cooperation with a core tube for recording data relating to the orientation of the core tube, and the control unit (12) is adapted to cooperate with the downhole unit to receive and process orientation data from the downhole unit and provide an indication of the orientation of a core sample within the core tube at a time prior to separation of the core sample from the underground environment from which it was obtained. The downhole unit (11) is configured to cooperate with the control unit (12) to establish an operative connection therebetween. More particularly, the downhole unit (11) and the control unit (12) are configured to provide a coupling (23) for releasably connecting them together in a manner allowing selective rotation therebetween. The coupling (23) comprises a combination of magnetic coupling and mechanical coupling.

Modular Core Orientation System

Field of the Invention

This invention relates to core sample orientation. More particularly, the invention relates to a core sample orientation system for providing an indication of the orientation of a core sample relative to the underground environment from which the core sample has been extracted, and also to a method of core sample orientation identification.

Background Art

The following discussion of the background art is intended to facilitate an understanding of the present invention only. The discussion is not an acknowledgement or admission that any of the material referred to is or was part of the common general knowledge as at the priority date of the application.

There is a need for core sampling in geological surveying operations.

Core samples are obtained through core drilling operations. Core drilling is typically conducted with a core drill comprising outer and inner tube assemblies. The inner tube assembly is known as a core tube. A cutting head is attached to the outer tube assembly so that rotational torque applied to the outer tube assembly is transmitted to the cutting head. A core is generated during the drilling operation, with the core progressively extending along the core tube as drilling progresses. When a core sample is required, the core within the core tube is fractured. The core tube and the fractured core sample contained therein are then retrieved from within the drill hole, typically by way of a retrieval cable lowered down the drill hole. Once the core tube has been brought to ground surface, the core sample can be removed and subjected to the necessary analysis.

Typically, the core drilling operation is performed at an angle to the vertical, and it is desirable for analysis purposes to have an indication of the orientation of the core sample relative to the underground environment from which it was extracted. It is therefore important that there be some means of identifying the orientation the

core sample had within the underground environment prior to it having been brought to the surface.

Core orientation devices are used to provide an indication of the orientation of the core sample. Many of these devices are mechanical in nature.

The applicant's international application PCT/AU2005/001344 (WO 2006/024111) discloses a core orientation device which records orientation information electronically and processes the information to provide an indication of the orientation of the extracted core sample relative to the underground environment from which it was extracted. The device comprises a tool which is adapted to be coupled to the core tube. The tool incorporates means for determining and storing the orientation of the tool at predetermined time intervals relative to a reference time, means for inputting a selected time interval, means for relating the selected time interval to one of the predetermined time intervals and providing an indication of the orientation of the device at the selected time interval, means for comparing the orientation of the tool at the selected time interval to the orientation of the tool at any subsequent time and providing an indication of the direction in which the tool should be rotated in order to bring it into an orientation corresponding to the orientation of the tool at the selected time. Thus the core sample confined within the core tube is brought into an orientation corresponding to its original orientation in the underground environment. The core sample can then be marked prior to being withdrawn from within the core tube.

All componenty required for operation of the device, including sensors, microprocessor, memory, circuitry and associated circuit boards, power supply, keypad and visual display unit (LCD) are incorporated in the tool and so are deployed in the borehole with the tool.

It would be advantageous to isolate some of the componentry from the borehole so that it is not vulnerable to damage arising from the arduous conditions to which the tool is typically exposed while down the borehole.

Disclosure of the Invention

According to a first aspect of the invention there is provided a core orientation system comprising a first portion adapted for cooperation with a core tube for recording data relating to the orientation of the core tube, and a second portion adapted to cooperate with the first potion to receive and process orientation data from the first portion and provide an indication of the orientation of a core sample within the core tube at a time prior to separation of the core sample from the underground environment from which it was obtained, the first and second portions being adapted for cooperation in a manner allowing selective rotation therebetween.

With such an arrangement, the first portion can be deployed underground with the core tube to record data corresponding to the orientation of the core tube (and any core sample contained therein). Once the core tube, along with the first portion attached thereto, has been retrieved from underground, the second portion can be brought into cooperation with the first portion to receive and process the orientation data received from the first portion. This arrangement is advantageous as it is not necessary for the second portion to travel underground and be exposed to the harsh conditions associated therewith.

Typically, the first portion adapted for cooperation with a core tube by being adapted for connection to the core tube for rotational movement in unison therewith. The first portion may be adapted for connection with the core tube, either directly or indirectly. The first portion may be directly connected to the core tube, typically (although not necessarily) through a threaded connection therebetween. The first portion may be indirectly connected to the core tube by being accommodated within a housing which is connected to the core tube, typically (although not necessarily) through a threaded connection.

Preferably, there is provided a coupling for releasably coupling the two portions together to provide the cooperation allowing selective rotation therebetween. Typically, the coupling is so configured that the second portion can dock onto the first portion. The coupling may comprise a combination of magnetic coupling and mechanical coupling.

In particular, the coupling is configured to allow selective rotation of the second portion relative to the first portion if desired to establish a desired orientation between the two portions.

The mechanical coupling may comprise a spigot formation associated with one of the two portions and a corresponding socket formation associated with the other of the two portions for providing alignment between the two portions when the spigot formation is received within the socket formation.

The magnetic coupling may comprise an attractive force between the two portions for biasing the spigot formation and the socket formation into engagement.

The spigot formation may be provided on the second portion and the corresponding socket formation may be associated with .the first portion. In one arrangement, the corresponding socket formation may be provided in the first portion. In another arrangement, the corresponding socket formation may be provided in a member associated with the first portion. The member may comprise the housing in which the first portion is accommodated.

The housing may comprise at least two parts adapted for connection together and selectively separable to provide access to the first portion accommodated therein.

Preferably, orientation data is transmitted from the first potion to the second portion by wireless communication. The wireless communication may comprise infrared (IR) short-range communication. With this arrangement, the first and second portions are each provided with an IR interface to facilitate IR communication therebetween.

It should be appreciated that orientation data may be transmitted from the first portion to the second portion in any other appropriate way, including a physical transmission link established between the first and second portions when they are coupled together.

The first potion may comprise a downhole unit and the second portion may comprise a control unit.

According to a second aspect of the invention there is provided a core orientation system comprising a first portion for recording orientation data and a second portion adapted to cooperate with the first potion to receive and process orientation data from the first portion, the first and second portions being adapted for cooperation in a manner allowing selective rotation therebetween.

According to a third aspect of the invention there is provided a survey tool system comprising a housing and a core orientation system, wherein the core orientation system comprises a first portion for recording data relating to the orientation of a core sample, and a second portion adapted to cooperate with the first potion to receive and process orientation data from the first portion and provide an indication of the orientation of the core sample at a time prior to separation of the core sample from the underground environment from which it was obtained, the first portion being contained within the housing, the housing comprising at least two parts adapted for connection together and selectively separable to permit the second portion to access the first portion for cooperation therebetween.

According to a fourth aspect of the invention there is provided a survey tool system comprising a housing, a downhole unit for recording data relating to the orientation of a core sample, and a control unit adapted to cooperate with the downhole unit to receive and process orientation data from the downhole unit and provide an indication of the orientation of the core sample at a time prior to separation of the core sample from the underground environment from which it was obtained, the downhole unit being contained within the housing, the housing comprising at least two parts adapted for connection together and selectively separable to permit the control unit to access the downhole for cooperation therebetween.

According to a fifth aspect of the invention there is provided a method of providing an indication of the orientation of a core sample relative to a body of material from which the core sample has been extracted, the method being performed using an orientation system according to the first or second aspect of the invention.

According to a sixth aspect of the invention there is provided a method of providing an indication of the orientation of a core sample relative to a body of

material from which the core sample has been extracted, the method being performed using an survey tool system according to the third or fourth aspect of the invention.

Brief Description of the Drawings

The invention will be better understood by reference to the following description of several specific embodiments thereof as shown in the accompanying drawings in which:

Figure 1 is a schematic view of a downhole unit forming part of a core sample orientation system according to the first embodiment;

Figure 2 is a schematic view of a control unit also forming part of the core sample orientation system

Figure 3 is a fragmentary schematic view of the control unit in operative engagement with the downhole unit;

Figure 4 is a schematic elevational view of a removable chassis forming part of the control unit;

Figure 5 is a side view of the chassis;

Figure 6 is a schematic view of a calibration unit for calibrating the downhole unit;

Figure 7 is a schematic view of a docking station for the control unit;

Figure 8 is a block diagram illustrating various components of the downhole unit;

Figure 9 a block diagram illustrating various components of the control unit;

Figure 10 is a sectional perspective view of a core sample orientation system according to the second embodiment, with the downhole unit

shown accommodated in part of a housing therefor, and the control unit shown coupled to the downhole unit;

Figure 11 a schematic view of an assembly in which the housing is accommodated and the control unit shown schematically in position in relation the housing;

Figure 12 a schematic view of one part of the housing, with the other part having been separated therefrom to provide access to a downhole unit accommodated in the first part, and a control unit shown for cooperation with the downhole unit;

Figure 13 is an end view of the control unit;

Figure 14 is a side elevational view of the housing;

Figure 15 is a side elevational view of the housing showing the two parts thereof in a separated condition; and;

Figure 16 is a sectional elevational view of the housing.

Best Mode(s) for Carrying Out the Invention

Referring to Figures 1 to 9, there is shown a core sample orientation system 10 according to the first embodiment comprising a first portion 11 and a second portion 12. The first portion 11 comprises a downhole unit adapted to be connected to a core tube (not shown) of a core drill of a type well known in the art. The second portion 12 comprises a control unit, as will be explained in more detail later.

The downhole unit 11 is configured for connection to the upper end of the core tube; specifically, by threaded engagement therewith. When so connected to the core tube, the downhole unit 11 is fixed for rotation with the core tube.

The downhole unit 11 comprises a cylindrical housing 15 having a first end 17, a second end 18, and a cylindrical side wall 19 extending between the two ends.

The side wall 19 has an outer periphery 21 configured and dimensioned to accord with the outer periphery of the core tube.

The first end 17 of the downhole unit incorporates a threaded section (not shown) for threaded engagement with a mating threaded section on the upper end of the core tube.

The downhole unit 11 is configured to cooperate with the control unit 12 to establish an operative connection therebetween, as will be explained in more detail later. More particularly, the downhole unit 11 and the control unit 12 are configured to provide a coupling 23 for releasably connecting them together in a manner allowing selective rotation therebetween. The coupling 23 comprises a combination of magnetic coupling and mechanical coupling, as will be explained.

The coupling 23 comprises a socket formation 25 on at the second end 18 of the downhole unit 11 and a corresponding spigot formation 27 on the control unit 12 for providing alignment therebetween when the spigot formation 27 is received within the socket formation 25. The mechanical connection is established by engagement between the socket formation 25 and the spigot formation 27. The magnetic coupling provides an attractive force between the downhole unit 11 and the control unit 12 for biasing the spigot formation 27 and the socket formation 25 into engagement.

The socket formation 25 has an inner face 31 with a radially outer section 33 which incorporates a magnetic element 35. The spigot formation 27 has an outer face 37 with a radially outer section 41 which incorporates a further magnetic element 43. The two magnetic elements 35, 43 cooperate to establish the magnetic attractive force between the two portions 11, 12 when the spigot formation 27 is received within the socket formation 25.

The control unit 12 comprises a generally circular body 51 having an outer face 53, an inner face 55 and a circular outer peripheral wall 57. The spigot formation 27 is incorporated in the body 51 and projects axially from the inner face 55.

The body 51 is configured so as to be of a shape and size that can be readily grasped and manipulated by hand, even when the operator is wearing protective gloves.

The body 51 has an interior region 61 accommodating a removable chassis 63 which carries a circuit board 65 and related componentry. With this arrangement, either the body 51 or the chassis 63 can be replaced as necessary in the event that any component thereof becomes defective.

The body 51 also accommodates a power supply 67 in the form of a lithium battery pack, and an IR interface 68 which is disposed within the spigot formation 27.

The outer face 53 of the body 51 incorporates an input device 69 in the form of a keypad and a visual display device 71 in the form of a liquid crystal display unit.

The chassis 63 carries a processing means 73 in the form of low power microcontroller, a memory device 75 providing non-volatile memory, a timer 77 and a watchdog circuit 79.

The housing 15 of the downhole unit 11 has an internal cavity 81 which accommodates a module 83 incorporating a triaxial accelerometer means 85, an analogue-to-digital converter 87, a processing means 89 in the form of low power microcontroller, a memory device 91 providing non-volatile memory, a power supply 92 in the form of a lithium battery pack and a watchdog circuit 93. Further, the module 83 is provided with an IR interface 95. With this arrangement, the downhole unit 11 can record data relating to its orientation (and thus the orientation of the core tube to which it is attached). When the downhole unit 11 is retrieved from the borehole (along with the core tube and a core sample therein), and the control unit 12 then coupled to the downhole unit 11 as previously described, orientation data recorded by the downhole unit 11 is transmitted wirelessly to the control unit 12 through operative cooperation between the two IR interfaces 68, 95. The control unit 12 receives and processes orientation data from the downhole unit 11 and provides an indication of the orientation of a core sample within the core tube at a time prior to separation of the core sample from the underground environment from which it was obtained.

The orientation system 10 operates in a fashion similar to that described in aforementioned international application PCT/AU2005/001344 (WO 2006/024111), the contents of which are incorporated herein by way of reference. In particular, the triaxial accelerometer means 85 comprises three internal silicon accelerometers operating along orthogonal directions X, Y and Z. The three accelerometers measure components of the earth's gravitational field. Mathematically transforming the outputs from the three accelerometers allows the rotational orientation of the downhole unit 11 about its longitudinal axis to be determined. More particularly, the signals produced by the triaxial accelerometer means 85 are determinative of the change in orientation of the downhole unit and are transmitted to the analogue-to-digital converter 87 which in turn transmits signals or signal data to the microcontroller 89. The microcontroller 89 processes signals from the arrangement over predetermined time intervals.

When the downhole unit 11 is operational, the relative orientation of the tool is determined at regular time intervals by the processing means 89[. The processed data is stored in the memory of the memory device 91. In this embodiment, the time intervals at which the orientation is determined and stored comprises intervals of one minute, although other intervals are of course possible.

The watchdog circuit 93 is provided for watching the system. In instances where the downhole unit 11 shuts down while in the borehole, it can be reset at the surface. Similarly, the control unit 12 has the watchdog circuit 79 for resetting as necessary.

A calibration unit 97 (as shown in Figure 6) is provided for calibrating the downhole unit 11 as required to maintain its accuracy. The calibration unit 97 is configured to incorporate a spigot formation 98 for engagement with the socket formation 25 of the downhole unit 11.

A docking station 99 (as shown in Figure 7) is provided for supporting the control unit 12 when it is not in use and for charging the power supply 67 as necessary. The docking unit 99 incorporates a socket formation 101 for receiving the spigot formation 27 on the control unit 12.

The following process occurs in the operation of the downhole unit 11 connected to the core tube. A first step comprises activating the downhole unit 11 and establishing a reference time. The core drill having the core tube is moved down the borehole to a drilling location at which it is operated to drill a core sample. While the core drill is moved to the drilling location, and also while it is operating, the downhole unit 11 generates acceleration signals associated with the rotational orientation of the downhole unit 11 and the core tube to which it is attached. The processing means 89 then processes the signals to provide processed data from which a measure of rotational orientation of the downhole unit 11 at the drilling location can be established. The processed data is stored in memory device 91 for later recall such that the measure of the rotational orientation of the downhole unit can be obtained therefrom.

During the drilling operation, a core sample is progressively generated within the core tube. When the core sample is to be extracted, the core drill operator refers to a timer and notes or records the duration of time since the downhole unit was activated at the commencement of operation. Specifically, the operator either notes the full minute that has previously elapsed or waits until the next full minute elapses, and then records that time (as it must be recalled later). The operator then initiates the procedure for breaking the core sample from the body of material, ensuring that no rotation of the core tube occurs. The core tube is retrieved from the drill hole in the conventional manner.

When the core tube and the downhole unit 11 is at the surface, the control unit 12 is coupled to the downhole unit 11 in the manner previously explained. The coupling 23 allows the control unit 12 to be selectively rotated with respect to the downhole unit 11to establish the desired orientational relationship therebetween. This will, of course, require application of a rotational force between the downhole unit 11 and the control unit 12 sufficient to over-ride the magnetic attraction therebetween to permit the relative rotation to occur.

The orientation data collected by the downtool tool 11 is transmitted wirelessly to the control unit 12 through the IR interfaces for subsequent interrogation of the orientation data. The time reading recorded previously is entered into the control unit by way of the keyboard input device 69. The orientation data is processed in

relation to the time entry to determine the orientation of the downhole unit 11 (and hence the core tube and the core sample confined in the core tube) prior to breaking the core sample from the body of material. By using integration means and the prescribed time intervals the processed data is indicative of the change orientation of the downhole unit in the prescribed time intervals commencing from the reference time corresponding to the time at which the downhole unit was activated.

The control unit 12 processes the orientation data and provides a measure of the target orientation of the downhole unit 11 in relation to the current rotational orientation thereof. This allows for the downhole unit 11 to consequently be rotated to reflect the measure of the orientation of the core orientation device. The visual display device 71 displays a visual indication of the direction in which the downhole unit 11 and the core tube attached thereto should be rotated to attain the target orientation. Rotating the downhole unit 11 and the core tube attached thereto in the indicated direction causes the core sample contained within the core tube to move into the target orientation (corresponding to the orientation of the core sample at the time that the core sample was in the underground environment before extraction).

Once the required target orientation has been attained, the core sample within the core tube can be marked as necessary and then withdrawn from the core tube.

In this embodiment, the visual indication comprises a directional arrow arrangement showing the required rotational direction. Once the downhole unit is at the target orientation, the display may provide an image representing that condition. Other visual arrangements are, of course, possible. Further, the indication need not necessarily be a visual indication; for example, the indication may comprise any appropriate sensory indication including visual, audible, and tactile indications, as well as any combination thereof. Further, the nature of the indication may vary as the orientation of the rotating downhole unit approaches the target orientation. A visual indication may, for example, comprise a flashing signal which increases in frequency as the target orientation is approached. Similarly, an audible signal may comprise a series of discrete audible tones which increase in frequency as the target orientation is approached, or alternatively a

continuous audible signal which varies in tone as the target orientation is approached.

Referring now to Figures 10 to 16, there is shown a core sample orientation system 110 according to the second embodiment. The core sample orientation system 110 is similar in some respects to the core sample orientation system 10 according to the first embodiment and so corresponding reference numerals will be used to identify corresponding parts. The corresponding parts in the core sample orientation system 110 will not necessarily be described further.

In particular, the core sample orientation system 110 comprises downhole unit 11 and control unit 12 which feature coupling 23 therebetween. The coupling 23 comprises a combination of a magnetic connection and a mechanical connection.

The core sample orientation system 110 is designed for use in conjunction with a downhole assembly 111 comprising a core tube 113, a back-end portion 115 and a housing 117 installed between the core tube 113 and the back-end portion 115. The back-end portion 115 is of standard wire line construction and is normally connected directly to core tube 113; however, in this embodiment, the housing 117 is configured for installation between the core tube 113 and the back- end portion 115.

The housing 117 may be of a construction as described in the applicant's Australian Provisional Patent Application 2009900590 and corresponding international application filed under the Patent Cooperation treaty, the contents of both of which are incorporated herein by way of reference.

In the arrangement shown, the housing 117 incorporates a compartment 119 configured to accommodate the downhole unit 11. The downhole unit 11 is confined in the compartment 119 to move in unison with the housing 117, both in translation and rotation.

The housing 117 has a bottom end 121 adapted for connection to the upper end of the core tube 113, and an top end 123 adapted for connection to the back-end portion 115.

In this way, the downhole unit 11 is also connected to the core tube 113 so that it record data relative to the orientation of the core tube and any core sample contained therein.

The housing 117 comprises two parts, being lower body part 125 and an upper cap part 127. The two parts 125, 127 cooperate to define the compartment 119 for accommodating the downhole unit 11. The parts 125, 127 are selectively separable to provide access to the compartment 119. In the arrangement illustrated in Figure 15, the two parts 125, 127 are shown in the separated condition.

The lower body part 125 has an end 131 configured as a spigot 133, and the upper cap portion 127 has an adjacent end configured as a socket 137 in which the spigot 133 can be threadingly received to secure the two parts together. A sealing means 139 is provided to effect fluid-tight sealing engagement between the two parts 125, 127. In the arrangement illustrated, the sealing means 139 comprises O-rings on the spigot 133.

The housing 117 is configured to enable fluid to flow past the downhole assembly 111 as it descends within a borehole (or more particularly within the drill rods within the borehole). Preferably, the arrangement is such that the fluid can flow past the descending downhole assembly 111 at a rate sufficient to allow the assembly to descend rapidly.

The end 131 of the lower body part 125 configured as a spigot 133 is also configured as a socket formation 141 which performs a function similar to that of the socket formation 25 of the core sample orientation system 10 according to the first embodiment. Specifically, the socket formation 141 is adapted to receive the spigot formation 27 on the control unit 12. The spigot formation 27 and the socket formation 141 cooperate to provide the mechanical connection established by the coupling 23.

The end 143 of the downhole unit 11 adjacent the socket formation 141 presents an inner face 145 which incorporates a magnetic element 149. The magnetic element 149 cooperates with the magnetic element 43 on the spigot formation 27 on the control unit 12 to establish the magnetic attractive force between the two

portions 11, 12 when the spigot formation 27 is received within the socket formation 141. This arrangement provides the magnetic connection established by the coupling 23.

In Figure 10, the control unit 12 is shown coupled to downhole unit 11 while the lower body part 125 is within a drill string. This is merely for illustrative purposes only to show that the housing 117 and the overall assembly 111 can be received within the drill string. Typically, the assembly 111 is withdrawn from the drill string before the two parts 125, 127 are separated and the control unit 12 is connected to the downhole unit 11.

Operation of the downhole assembly 111 will now be described. The housing 117 is installed between the core tube 113 and the back-end portion 1115, as previously described to provide the assembly 111.

The two parts 125, 127 of the housing 117 are separated to allow installation of the downhole unit 11 into the compartment 119 and then coupled together to encase the downhole unit 11 within the compartment 119.

The assembly 111 is then lowered down the drill rods within the borehole in conventional manner. As the assembly 111 descends, fluid within the drill rods flows upwardly (relative to the descending assembly 111). Fuid within the drill rods is able to flow past the housing 117 as it descends within the drill rods and so the presence of the housing does not restrict fluid flow to such an extent to inhibit relatively rapid descent of the assembly 111.

At the completion of the core drilling operation, the core sample is retrieved in known manner. Once the assembly 111 is at ground level, the two parts 125, 127 of the housing 117 can be separated to provide access to the downhole unit 11 within the lower body part 125. The control unit 12 can then be brought into cooperation with the downhole unit 11, as shown in Figure 10, to receive and process the orientation data received from the downhole unit 11. Specifically, the socket formation 141 on the lower body part 125 receives the spigot formation 27 on the control unit 12. The spigot formation 27 and the socket formation 141 cooperate to provide the mechanical connection established by the coupling 23. Further, the magnetic element 149 on end 143 of the downhole unit 11within the

lower body part 125 cooperates with the magnetic element 43 on the spigot formation 27 on the control unit 12 to provide the magnetic connection established by the coupling 23.

The coupling 23 allows the control unit 12 to be selectively rotated with respect to the downhole unit 11 to establish the desired orientational relationship therebetween, as was the case with the first embodiment.

Once the orientation of the core sample within the core tube 113 has been established and recorded, the core sample can be removed from the core tube. The two parts 125, 127 of the housing 117 can then be brought together again to encase the downhole unit 11 within the housing so that the next core sampling operation can be performed when required.

From the foregoing it is evident that the present embodiments each provides a modular core sample orientation system involving the downhole unit 11 and the control unit 12 as separate parts. Because the control unit 12 is separate from the downhole unit 11 and is not deployed in the borehole during the core sampling operation, it is isolated from the rigours to which the downhole unit 11 is exposed during deployment. Similarly, the control unit is isolated from the rigours to which unitary core orientation tools (such as the tool disclosed in aforementioned international application PCT/AU2005/001344) are exposed when in boreholes.

Modifications and improvements may be made without departing from the scope of the invention. For example in other embodiment the physical orientation need not comprise a rotational orientation but rather a measure of degrees above or below the horizontal plane.

Throughout the specification and claims, unless the context requires otherwise, the word "comprise" or variations such as "comprises" or "comprising", will be understood to imply the inclusion of a stated integer or group of integers but not the exclusion of any other integer or group of integers.

The Claim Defining the Invention is as Follows:

1. A core orientation system comprising a first portion adapted for cooperation with a core tube for recording data relating to the orientation of the core tube, and a second portion adapted to cooperate with the first potion to receive and process orientation data from the first portion and provide an indication of the orientation of a core sample within the core tube at a time prior to separation of the core sample from the underground environment from which it was obtained, the first and second portions being adapted for cooperation in a manner allowing selective rotation therebetween.

2. The core orientation system according to claim 1 wherein the first portion is adapted for cooperation with a core tube by being adapted for connection to the core tube for rotational movement in unison therewith.

3. The core orientation system according to claim 2 wherein first portion is adapted for direct connection with the core tube.

4. The core orientation system according to claim 2 wherein first portion is adapted for direct connection with the core tube.

5. The core orientation system according to claim 4 wherein first portion is adapted to be accommodated within a housing adapted for connection to the core tube.

6. The core orientation system according to any one of the preceding claims further comprising a coupling for releasably coupling the two portions together.

7. The core orientation system according to claim 6 wherein the coupling is so configured that the second portion can dock onto the first portion.

8. The core orientation system according to claim 6 or 7 wherein the coupling is configured to allow selective rotation of the second portion relative to the first portion.

9. The core orientation system according to claim 6, 7 or 8 wherein the coupling comprises a mechanical coupling.

10. The core orientation system according to any one of claims 6 to 9 wherein the coupling comprises a magnetic coupling.

11. The core orientation system according to any one of claims 6 to 9 wherein the coupling comprises a combination of magnetic coupling and mechanical coupling.

12. The core orientation system according to claim 9, 10 or 11 wherein the mechanical coupling comprises a spigot formation associated with one of the two portions and a corresponding socket formation associated with the other of the two portions for providing alignment between the two portions when the spigot formation is received within the socket formation.

13. The core orientation system according to claim 12 wherein the magnetic coupling comprises an attractive force between the two portions for biasing the spigot formation and the socket formation into engagement.

14. The core orientation system according to claim 12 or 13 wherein the spigot formation is provided on the second portion and the corresponding socket formation may be associated with .the first portion.

15. The core orientation system according to claim 14 wherein the corresponding socket formation is provided in the first portion.

16. The core orientation system according to claim 14 wherein the corresponding socket formation is provided in a member associated with the first portion. ,

17. The core orientation system according to claim 16 wherein the member comprises a housing accommodating the first portion..

18. The core orientation system according claim 17 wherein the housing at least two parts adapted for connection together and selectively separable to provide access to the first portion accommodated therein.

19. The core orientation system according to any one of the preceding claims wherein orientation data is transmitted from the first potion to the second portion by wireless communication.

20. The core orientation system according to any one of the preceding claims wherein the first potion comprises a downhole unit and the second portion comprises a control unit.

21. A core orientation system comprising a first portion for recording orientation data and a second portion adapted to cooperate with the first potion to receive and process orientation data from the first portion, the first and second portions being adapted for cooperation in a manner allowing selective rotation therebetween.

22. A survey tool system comprising a housing and a core orientation system, wherein the core orientation system comprises a first portion for recording data relating to the orientation of a core sample, and a second portion adapted to cooperate with the first potion to receive and process orientation data from the first portion and provide an indication of the orientation of the core sample at a time prior to separation of the core sample from the underground environment from which it was obtained, the first portion being contained within the housing, the housing comprising at least two parts adapted for connection together and selectively separable to permit the second portion to access the first portion for cooperation therebetween.

23. A survey tool system comprising a housing , a downhole unit for recording data relating to the orientation of a core sample, and a control unit adapted

to cooperate with the downhole unit to receive and process orientation data from the downhole unit and provide an indication of the orientation of the core sample at a time prior to separation of the core sample from the underground environment from which it was obtained, the downhole unit being contained within the housing, the housing comprising at least two parts adapted for connection together and selectively separable to permit the control unit to access the downhole for cooperation therebetween.

24. A method of providing an indication of the orientation of a core sample relative to a body of material from which the core sample has been extracted, the method being performed using an orientation system according to any one of claims 1 to 21.

25. A method of providing an indication of the orientation of a core sample relative to a body of material from which the core sample has been extracted, the method being performed using an tool survey system according to claim 22 or 23.

26. A core orientation system substantially as herein described with reference to the accompanying drawings.

27. A survey tool system substantially as herein described with reference to the accompanying drawings.

AMENDED CLAIMS
received by the International Bureau on 01 June 2010 (01.06.10)

1. A core orientation system comprising a first portion adapted for cooperation with a core tube for recording data relating to the orientation of the core tube, and a second portion adapted to cooperate with the first potion to receive and process orientation data from the first portion and provide an indication of the orientation of a core sample within the core tube at a time prior to separation of the core sample from the underground environment from which it was obtained, the first and second portions being adapted for cooperation in a manner allowing selective rotation therebetween.

2. The core orientation system according to claim 1 wherein the first portion is adapted for cooperation with a core tube by being adapted for connection to the core tube for rotational movement in unison therewith.

3. The core orientation system according to claim 2 wherein first portion is adapted for direct connection with the core tube.

4. The core orientation system according to claim 3 wherein first portion is adapted to be accommodated within a housing adapted for connection to the core tube.

5. The core orientation system according to any one of the preceding claims further comprising a coupling for releasably coupling the two portions together.

6. The core orientation system according to claim 5 wherein the coupling is so configured that the second portion can dock onto the first portion.

7. The core orientation system according to claim 5 or 6 wherein the coupling is configured to allow selective rotation of the second portion relative to the first portion.

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8. The core orientation system according to claim 5, 6 or 7 wherein the coupling comprises a mechanical coupling.

9. The core orientation system according to any one of claims 5 to 8 wherein the coupling comprises a magnetic coupling.

10. The core orientation system according to any one of claims 5 to 8 wherein the coupling comprises a combination of magnetic coupling and mechanical coupling.

11. The core orientation system according to claim 8, 9 or 10 wherein the mechanical coupling comprises a spigot formation associated with one of the two portions and a corresponding socket formation associated with the other of the two portions for providing alignment between the two portions when the spigot formation is received within the socket formation.

12. The core orientation system according to claim 11 wherein the magnetic coupling comprises an attractive force between the two portions for biasing the spigot formation and the socket formation into engagement.

13. The core orientation system according to claim 11 or 12 wherein the spigot formation is provided on the second portion and the corresponding socket formation may be associated with .the first portion.

14. The core orientation system according to claim 13 wherein the corresponding socket formation is provided in the first portion.

15. The core orientation system according to claim 13 wherein the corresponding socket formation is provided in a member associated with the first portion. ,

16. The core orientation system according to claim 15 wherein the member comprises a housing accommodating the first portion..

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17. The core orientation system according claim 16 wherein the housing at least two parts adapted for connection together and selectively separable to provide access to the first portion accommodated therein.

18. The core orientation system according to any one of the preceding claims wherein orientation data is transmitted from the first potion to the second portion by wireless communication.

19. The core orientation system according to any one of the preceding claims wherein the first potion comprises a downhole unit and the second portion comprises a control unit.

20. A core orientation system comprising a first portion for recording orientation data and a second portion adapted to cooperate with the first potion to receive and process orientation data from the first portion, the first and second portions being adapted for cooperation in a manner allowing selective rotation therebetween.

21. A survey tool system comprising a housing and a core orientation system, wherein the core orientation system comprises a first portion for recording data relating to the orientation of a core sample, and a second portion adapted to cooperate with the first potion to receive and process orientation data from the first portion and provide an indication of the orientation of the core sample at a time prior to separation of the core sample from the underground environment from which it was obtained, the first portion being contained within the housing, the housing comprising at least two parts adapted for connection together and selectively separable to permit the second portion to access the first portion for cooperation therebetween.

22. A survey tool system comprising a housing , a downhole unit for recording data relating to the orientation of a core sample, and a control unit adapted to cooperate with the downhole unit to receive and process orientation data from the downhole unit and provide an indication of the orientation of the core sample at a time prior to separation of the core sample from the

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underground environment from which it was obtained, the downhole unit being contained within the housing, the housing comprising at least two parts adapted for connection together and selectively separable to permit the control unit to access the downhole for cooperation therebetween.

23. A method of providing an indication of the orientation of a core sample relative to a body of material from which the core sample has been extracted, the method being performed using an orientation system according to any one of claims 1 to 20.

24. A method of providing an indication of the orientation of a core sample relative to a body of material from which the core sample has been extracted, the method being performed using an tool survey system according to claim 21 or 22.

25. A core orientation system substantially as herein described with reference to the accompanying drawings.

26. A survey tool system substantially as herein described with reference to the accompanying drawings.

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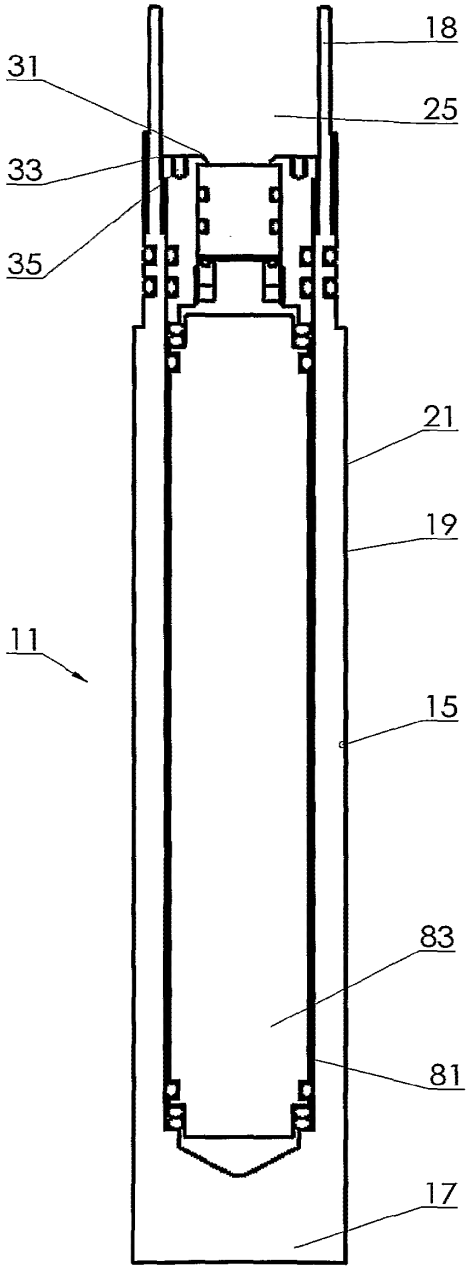


Fig.1

SUBSTITUTE SHEET (RULE 26)

Fig.2

Fig.3

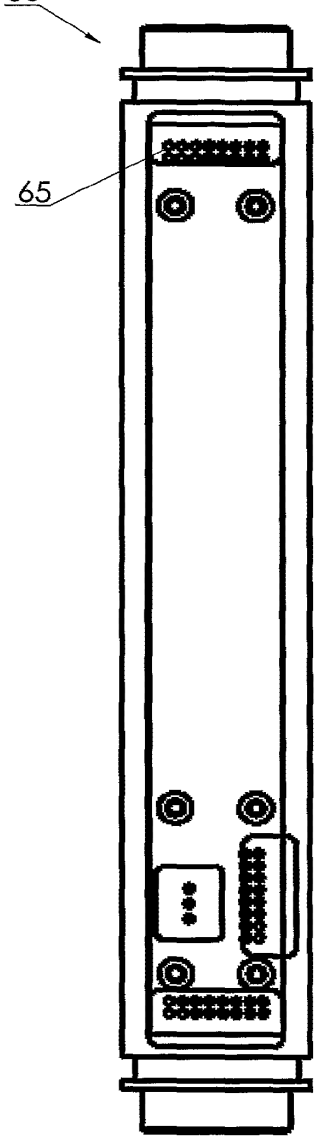


Fig.4

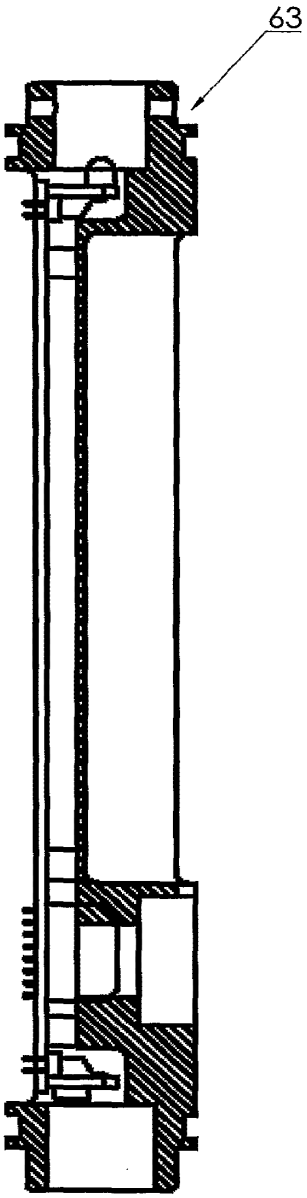


Fig.5

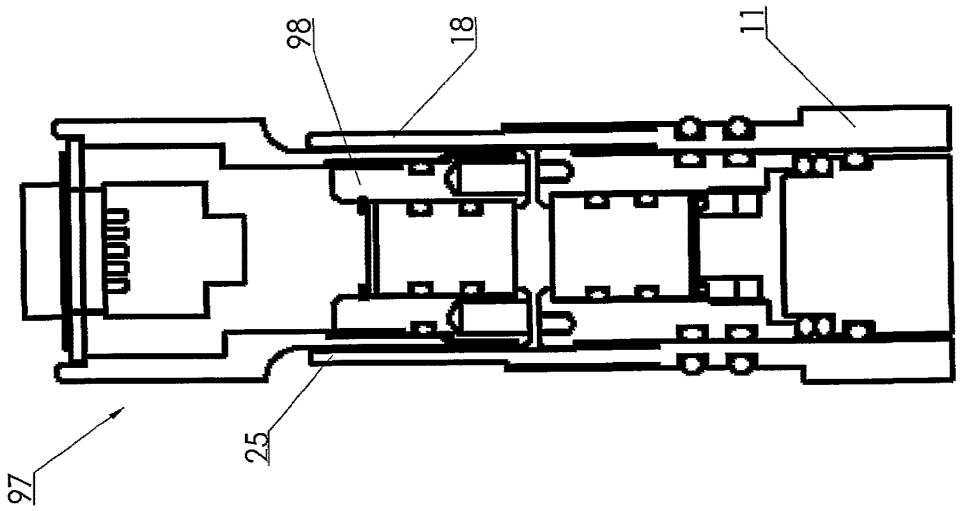


Fig.6

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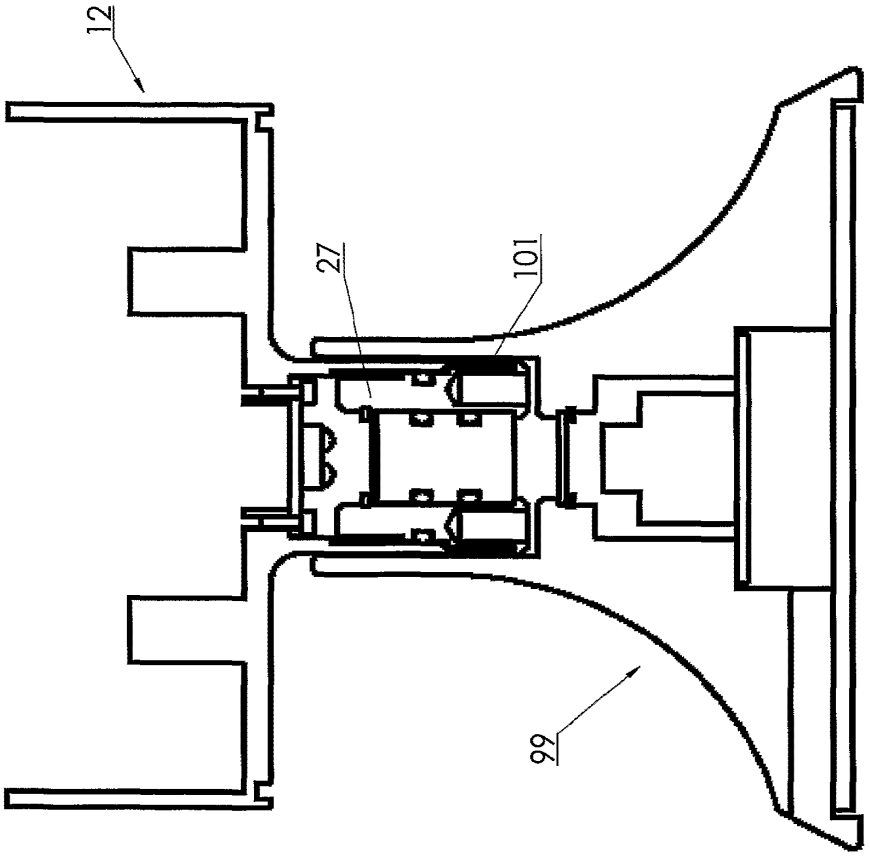


Fig.7

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Downhole tool:

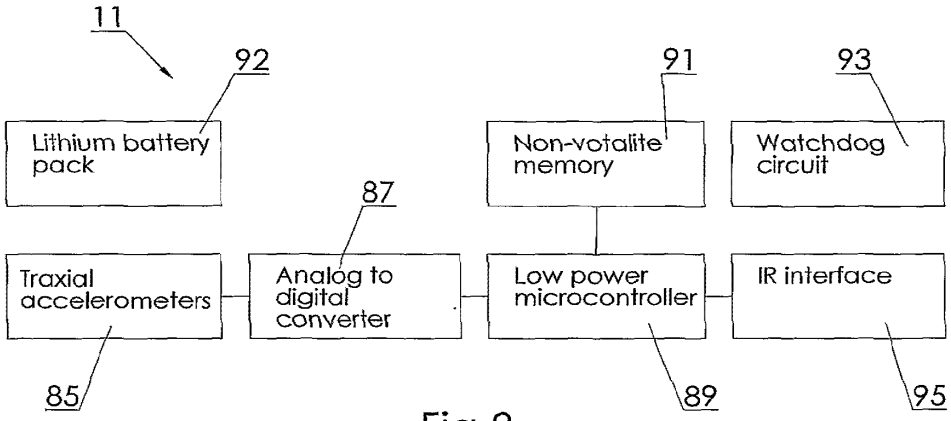


Fig.8

Control unit:

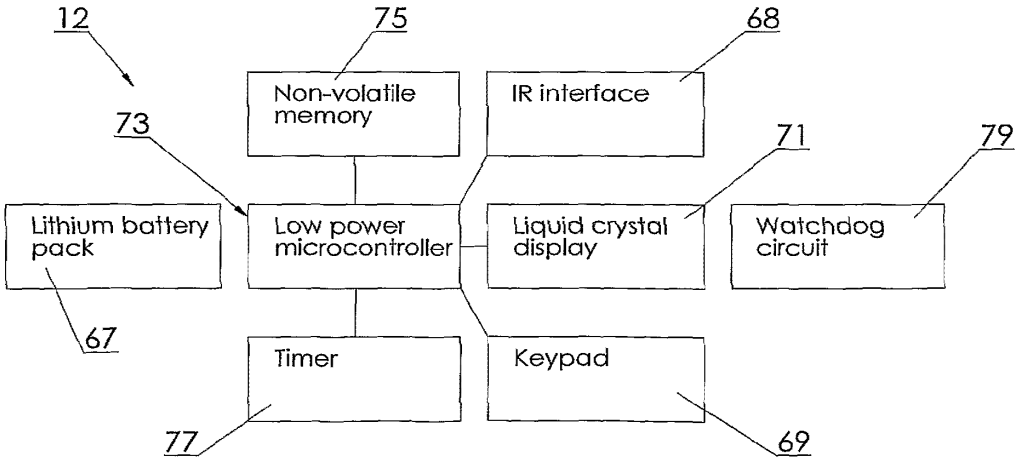


Fig.9

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FIG. 10

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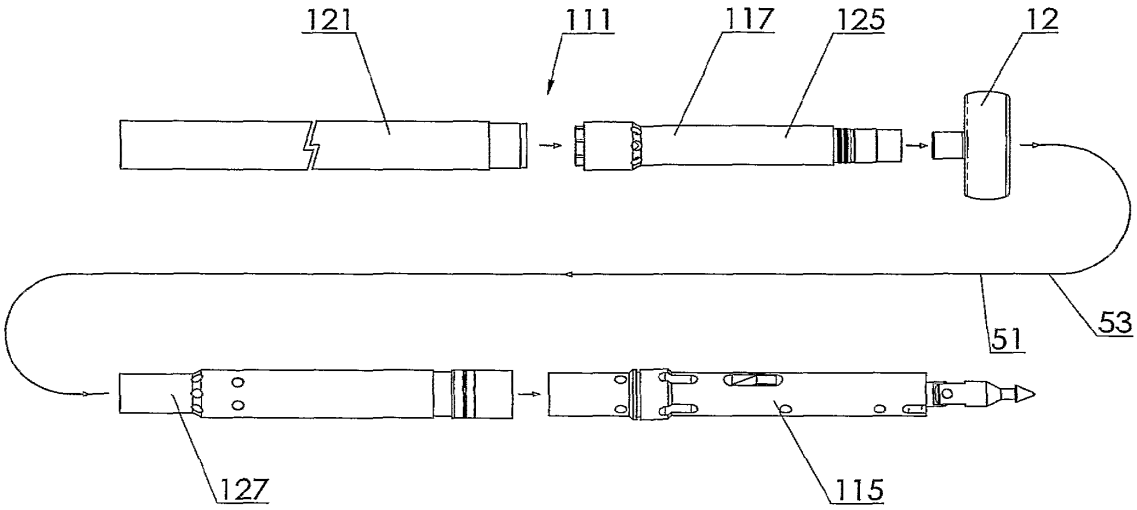


FIG. 11

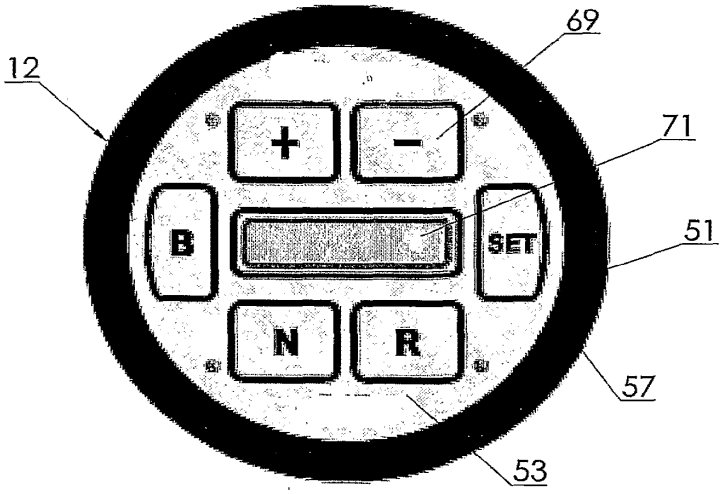


FIG. 13

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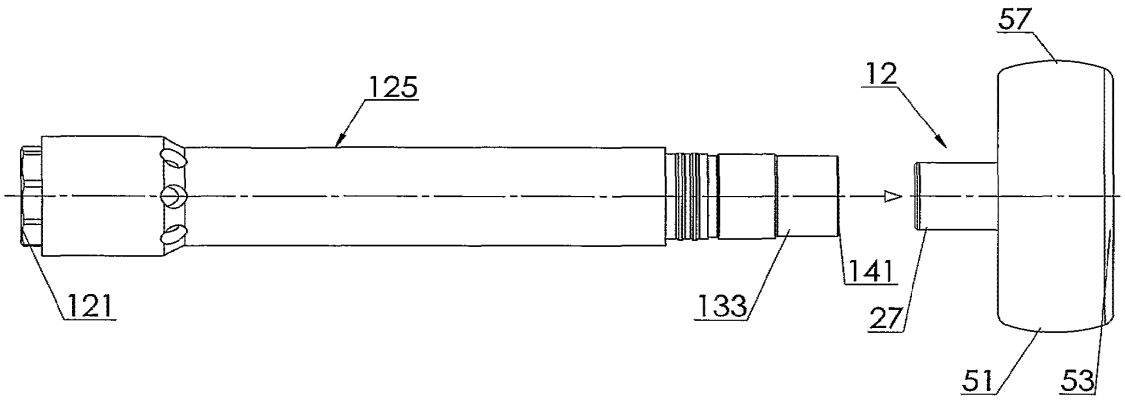


FIG. 12

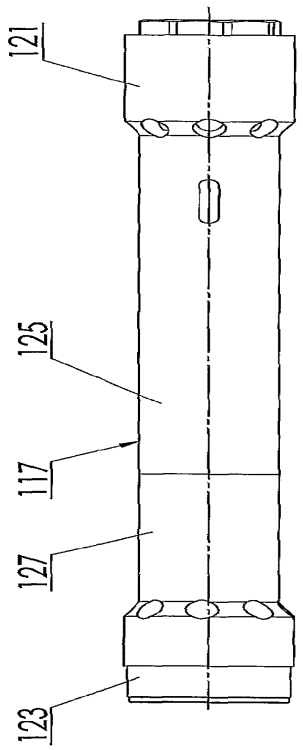


FIG. 14

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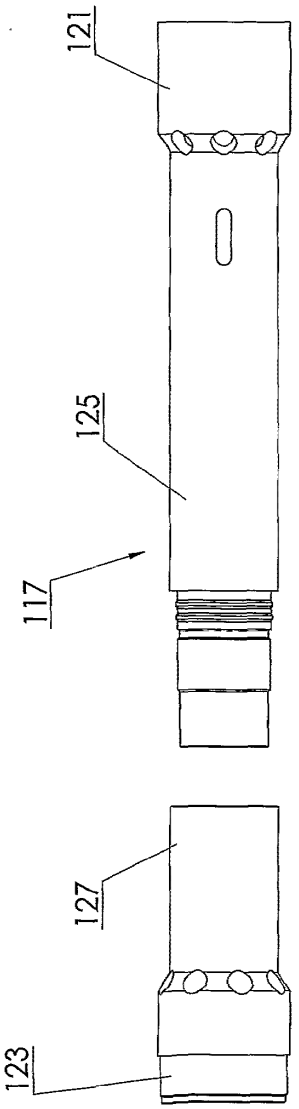


FIG. 15

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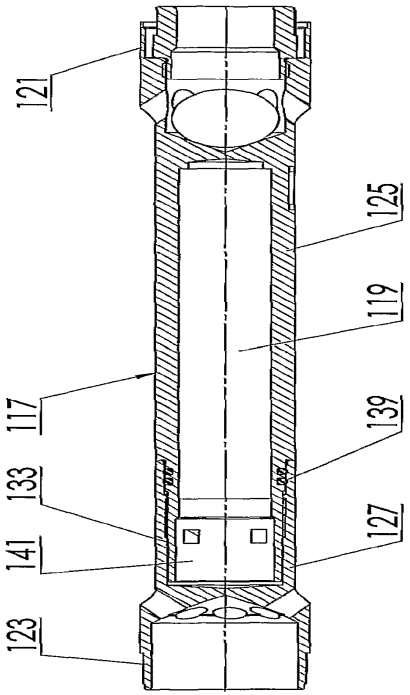


FIG.16

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/AU2010/000165

A. CLASSIFICATION OF SUBJECT MATTER

Int. Cl.

E21B 25/16 (2006.01) ***E21B 47/024*** (2006.01)

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)

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

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
WPI, EPODOC E21B 25/16, 47/024 key words CORE+, SELECT+, DIFFEREN+, SEPARA+, ROTAT+, TRANSFER, COMMUNICAT+, EXCHANGE, TRANSMIT+, RELAY+, SIGNAL+, PROCESS+, WIRELESS, INFRA_RED, IR

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	CA 2456506 C (SCOTT) 21 November 2006 Figs 1-4 & abstract	1-25
A	US 2007/0282533 A1 (PARFITT) 6 December 2007 Figs 1-6 & abstract	1-25
A	WO 2008/113127 A1 (2iC AUSTRALIA PTY LTD) 25 September 2008 Abstract & figs	1-25

☐ 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	Date of mailing of the international search report
12 March 2010	18 MAR 2010
Name and mailing address of the ISA/AU AUSTRALIAN PATENT OFFICE PO BOX 200, WODEN ACT 2606, AUSTRALIA. E-mail address: pct@ipaustralia.gov.au Facsimile No. +61 2 6283 7999	Authorized officer **SARAVANAMUTHU PONNAMPALAM** AUSTRALIAN PATENT OFFICE (ISO 9001 Quality Certified Service) Telephone No :

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/AU2010/000165

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. [ ] Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. [X] Claims Nos.: **26, 27**
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

The claims do not comply with Rule 6.2(a) because they rely on references to the description and/or drawings.

3. [ ] Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a)

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

I Claims 1-21 & 24
II Claims 22, 23 & 25

Please see separate sheet

1. [ ] As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. [X] As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.
3. [ ] As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. [ ] No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

[ ] The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.

[ ] The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.

[ ] No protest accompanied the payment of additional search fees.

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.
PCT/AU2010/000165

This Annex lists the known "A" publication level patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent Document Cited in Search Report		Patent Family Member					
CA	2456506	NONE					
US	2007282533	AU	2005256104	AU	2006100113	AU	2010200162
		BR	PI0515621	CA	2559030	MX	2007002643
		US	7584055	US	2009314545	WO	2006024111
		ZA	200701750				
WO	2008113127	AU	2008100249	AU	2008229644	EP	2134921

Due to data integration issues this family listing may not include 10 digit Australian applications filed since May 2001.

END OF ANNEX

Supplemental Box
(To be used when the space in any of Boxes I to IV is not sufficient)

Continuation of Box No: III

This International Application does not comply with the requirements of unity of invention because it does not relate to one invention or to a group of inventions so linked as to form a single general inventive concept.

In assessing whether there is more than one invention claimed, I have given consideration to those features which can be considered to potentially distinguish the claimed combination of features from the prior art. Where different claims have different distinguishing features they define different inventions.

This International Searching Authority has found that there are different inventions as follows:

- Claims 1-21 & 24 are directed to a core orientation system. It is considered that the first and second portions being adapted for cooperation in a manner allowing selective rotation there between comprises a first distinguishing feature.

- Claims 22, 23 & 25 are directed to a survey tool system. It is considered that the housing comprising at least two parts adapted for connection together and selectively separable to permit the second portion to access the first portion for cooperation there between comprises a second distinguishing feature.

PCT Rule 13.2, first sentence, states that unity of invention is only fulfilled when there is a technical relationship among the claimed inventions involving one or more of the same or corresponding special technical features. PCT Rule 13.2, second sentence, defines a special technical feature as a feature which makes a contribution over the prior art.

Each of the abovementioned groups of claims has a different distinguishing feature and they do not share any feature which could satisfy the requirement for being a special technical feature. Because there is no common special technical feature it follows that there is no technical relationship between the identified inventions. Therefore the claims do not satisfy the requirement of unity of invention *a priori*.

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(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
28 March 2013 (28.03.2013)

WIPO | PCT

(10) International Publication Number
WO 2013/040641 A1

(51) International Patent Classification:
E21B 25/16 (2006.01) *E21B 31/18* (2006.01)
E21B 47/00 (2012.01)

(21) International Application Number:
PCT/AU2012/001132

(22) International Filing Date:
20 September 2012 (20.09.2012)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
2011903859 20 September 2011 (20.09.2011) AU

(71) Applicant *(for all designated States except US)*: **IMDEX GLOBAL B.V.** [NL/NL]; Herikerbergweg 238, NL-1101CM Amsterdam Zuidoost (NL).

(72) Inventors; and

(71) Applicants *(for US only)*: **BROWN, Kelvin** [AU/AU]; 2 Barracuda Court, Sorrento, Western Australia 6020 (AU). **JABBAL, Guru** [AU/AU]; 69 Galileo Avenue, Tapping, Western Australia 6056 (AU). **TRANT, Dominic** [GB/GB]; Highlands Avenue, Ridgewood, Uckfield, Sussex TN22 5TD (GB). **GERASIMOFF, Michael** [CA/AU]; 12/186 Tyler Street, Tuart Hill, Western Australia 6060 (AU).

(74) Agent: **WRAYS**; Ground Floor, 56 Ord Street, West Perth, Western Australia 6005 (AU).

(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, 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, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, 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, LR, LS, MW, MZ, NA, RW, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:

— *with international search report (Art. 21(3))*

WO 2013/040641 A1

(54) Title: BOREHOLE SURVEYING TOOL DEPLOYMENT

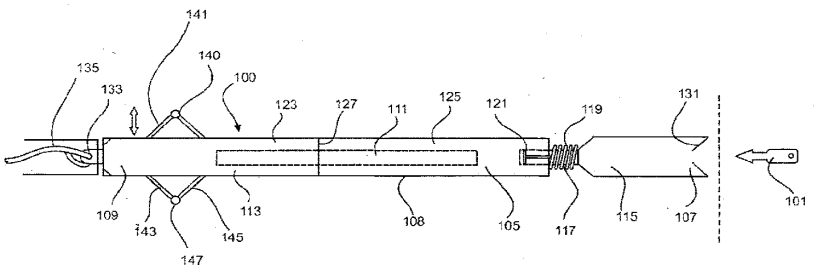


FIG 4

(57) Abstract: An apparatus for use in a downhole survey in conjunction with core sampling comprises a body adapted to receive a downhole surveying instrument, whereby the downhole surveying instrument can be conveyed along a borehole with the apparatus and operated in the borehole.

Borehole Surveying Tool Deployment

FIELD OF THE INVENTION

[0001] This invention relates to borehole surveying operations. In particular the invention relates to core sampling in borehole surveying operations.

BACKGROUND ART

[0002] The following discussion of the background art is intended to facilitate an understanding of the present invention only. The discussion is not an acknowledgement or admission that any of the material referred to is or was part of the common general knowledge as at the priority date of the application.

[0003] There is a need for core sampling in borehole surveying operations.

[0004] Core samples are obtained through core drilling operations. Core drilling is typically conducted with a core drill comprising outer and inner tube assemblies. The inner tube assembly comprises a core inner tube. A cutting head is attached to the outer tube assembly so that rotational torque applied to the outer tube assembly is transmitted to the cutting head. A core is generated during the drilling operation, with the core progressively extending along the core inner tube as drilling progresses. When a core sample is required, the core within the core inner tube is fractured. The inner tube assembly and the fractured core sample contained therein are then retrieved from within the drill hole, typically by way of a retrieval cable (which is commonly referred to as a wireline) lowered down the drill hole. Once the inner tube assembly has been brought to ground surface, the core sample can be removed from the core inner tube and subjected to the necessary analysis.

[0005] The inner tube assembly further comprises a backend assembly which includes a spearhead point releasably engagable with an overshot attached to the end of the wireline. With this arrangement, the inner tube assembly can be lowered into, and retrieved from, the outer tube assembly and the drill string to which the outer tube assembly is connected.

[0006] During a borehole drilling operation there is a need to survey the path of the borehole to determine if the trajectory is being maintained within acceptable limits. Surveying a borehole is usually accomplished using a

surveying tool which is moved along the borehole to obtain the information required, or at least data from which the required information can be determined. Information in relation to the path of a borehole can typically include inclination, azimuth and depth.

[0007] Surveying tools typically contain sensor devices for measuring the direction and magnitude of the local gravitational field, the Earth's magnetic field and/or the rate of rotation of the Earth. These measurements correspond to the position and orientation of the surveying tool in the borehole. The position, inclination and/or azimuth can be calculated from these measurements.

[0008] The sensor devices can comprise accelerometers for measuring the direction and magnitude of the local gravitational field, magnetometers for measuring the Earth's magnetic field and/or gyroscopes for measuring the rate of rotation of the Earth, from which azimuth can be calculated.

[0009] Typically, the core drilling operation is performed at an angle to the vertical, and it is desirable for analysis purposes to have an indication of the orientation of the core sample relative to the underground environment from which it was extracted. It is therefore important that there be some means of identifying the orientation the core sample had within the underground environment prior to it having been brought to the surface.

[0010] Core orientation devices are used to provide an indication of the orientation of the core sample.

[0011] The applicant's International application PCT/AU2011/000628 discloses a down hole surveying system for directional surveying of boreholes. The down hole surveying system is configured as a tool comprising a body which is sized and shaped for movement along a borehole in down hole surveying applications. The body accommodates sensor devices comprising a gyroscope and an accelerometer.

[0012] Downhole surveying operations and core retrieval are typically conducted as separate operations. In particular, it is customary to perform a surveying operation once the inner tube assembly has been removed from the drill pipe/rod during retrieval of a core sample. This involves retrieving the inner tube assembly using an overshot attached to the end of the wireline, and then

lowering a down hole survey instrument into the borehole to perform the surveying operation. The surveying instrument is then raised and removed from the borehole and the inner tube assembly returned into position for the next core sampling operation.

[0013] Consequently, there is downtime for both downhole surveying operations and core retrieval.

[0014] In would be advantageous for there to be at least some coordination between downhole surveying and core retrieval operations to thereby reduce downtime while the procedures are being performed.

[0015] Also, orientation of a bottom hole assembly and more recently core sample has been performed by using gravity based sensors, namely accelerometers, in angled/inclined drill hole applications. These systems have been able to orientate a pre-determined tool face of a bottom hole assembly down the borehole with a survey instrument by referencing the tool face of the bottom hole assembly to the known top dead centre position as determined by gravity based sensors.

[0016] In vertical drilling applications where the inclination of the bottom hole assembly is within 5 degrees of the vertical plane it is not possible to use gravimetric sensors as a reference to top dead centre with any acceptable accuracy. In such applications, magnetic based sensors such as magnetometers can be used to reference the bottom hole assembly tool face to magnetic North but are subject to influence from magnetic sources such as the formation being drilled and the bottom hole assembly itself. The use of non-magnetic materials to manufacture the bottom hole assembly can overcome the magnetic influence from the bottom hole assembly but are still subject to influence from the information and this can render such a system inaccurate.

SUMMARY OF THE INVENTION

[0017] It is an object of the present invention to overcome, or at least ameliorate, one or more of the deficiencies of the prior art mentioned above, or to provide the consumer with a useful or commercial choice.

[0018] Other objects and advantages of the present invention will become apparent from the following description, taken in connection with the accompanying drawings, wherein, by way of illustration and example, a preferred embodiment of the present invention is disclosed.

[0019] According to a first broad aspect of the present invention there is provided an apparatus for use in a downhole survey in conjunction with core sampling, the apparatus comprising a body adapted to receive a downhole surveying instrument, whereby the downhole surveying instrument can be conveyed along a borehole with the apparatus and operated in the borehole.

[0020] The downhole surveying instrument may comprise a downhole survey tool or a component thereof.

[0021] The downhole surveying instrument may, for example, comprise a downhole tool comprising one or more sensor devices such as orthogonal accelerometers, magnetometers, gyroscopes, MEMS (microelectromechanical) gyro sensors, or any combination thereof.

[0022] A suitable downhole surveying instrument may comprise the downhole tool as described and illustrated in International application PCT/AU2011/000628, the contents of which are incorporated herein by way of reference. Other appropriate downhole tools can, of course, also be used.

[0023] Where the downhole surveying instrument comprises a geo-magnetic device, it may be necessary for the body, or at least relevant parts thereof, to be made of material or materials which do not interfere magnetically with the geo-magnetic device. In particular, the body, or at least relevant parts thereof, may need to be made of material which is non-magnetic.

[0024] Where the downhole surveying instrument does not comprise a geo-magnetic device, the body would not necessarily need to be made of materials which are non-magnetic. The downhole surveying tool described and illustrated in International application PCT/AU2011/000628 is an example of an arrangement in which the body would not necessarily need to be made of materials which are non-magnetic.

[0025] The body may incorporate a cavity for accommodating the downhole surveying instrument.

[0026] Preferably, the body is configured to facilitate installation of the downhole surveying instrument in the cavity. The body may, for example, be constructed in two or more parts, with one part being selectively separable from another part to provide access to the cavity.

[0027] The body may be adapted to provide cushioning to afford some impact protection for the surveying instrument. In particular, the body may be configured to cushion impact forces following descent into a borehole.

[0028] The cushioning may be provided by a cushioning mechanism incorporated in the body.

[0029] The cushioning mechanism may comprise an elastic structure such as a spring for absorbing a shock impact. The cushioning mechanism may further comprise a shock absorber for damping the spring oscillations.

[0030] Magnetic braking may be utilised to slow the apparatus as it approaches the end of its descent into a borehole. The apparatus may for example include at least a portion of a magnetic braking system for slowing the apparatus in this manner.

[0031] The apparatus may have provision for controlled positioning thereof within the borehole for operation of the surveying instrument. The controlled positioning provides stable support within the borehole.

[0032] Preferably, said provision for controlled positioning within the borehole for operation of the surveying instrument comprises means for engaging the surrounding portion of a drill string to provide stabilization with respect to the drill string.

[0033] The engaging means may be adapted to support the apparatus within the surrounding portion of the drill string in a circumferentially centred manner. With such an arrangement, the engaging means may be configured as a centraliser.

[0034] The engaging means may comprise radially disposed arms biased outwardly to contact sides of the drill string, thus centrally positioning the apparatus within the surrounding portion of the drill string. The arms may each include an outer contact portion configured for contact with the inner wall of the surrounding portion of the drill string. The outer contact portion may be of any appropriate form, such as a pad or a roller.

[0035] In one arrangement, the engaging means may be configured to engage the drill string for movement therealong as the apparatus is raised or lowered within the borehole. With this arrangement, the engaging means may comprise a fixed structure configured as a carriage for movement along the internal wall of the drill string.

[0036] In another arrangement, the engaging means may be adapted for movement between collapsed and extended conditions, whereby in the collapsed condition it is clear of the internal wall of the drill string for movement therealong and in the extended condition it is in engagement with the drill string for controlled positioning of the apparatus within the borehole to provide stable support for operation of the surveying instrument.

[0037] Actuation means may be provided for actuating the engaging means. The actuation means may be triggered by contact, or at least proximity, between the apparatus and another downhole member. By way of example, the actuation of the engaging means may be triggered by contact between an inner tube assembly and an overshot assembly.

[0038] The actuation means may be of any appropriate form; for example, the actuation means may comprise a mechanical actuator or some other arrangement such as magnetic switch, proximity detector or wireless transmission system

[0039] The apparatus may also be adapted to initiate operation of the downhole surveying instrument. By way of example, the apparatus may be adapted to initiate operation of the downhole surveying instrument as it approaches or completes the end of its descent into the borehole. In this regard, the apparatus may comprise means such as a shock logger for measuring rapid deceleration and transmitting a command to the downhole surveying instrument.

[0040] The apparatus may be of any appropriate form. The apparatus may, for example, comprise an inner tube assembly of a core drill, an overshot assembly, or an arrangement such as a sub or a drop tool assembly adapted for attachment to an inner tube assembly and/or to an overshot assembly.

[0041] According to a second broad aspect of the present invention there is provided an inner tube assembly comprising a body having an upper portion adapted for connection to a retrieval system and a lower portion adapted to receive a core sample during a drilling operation, the body being adapted to receive a downhole surveying instrument, whereby the downhole surveying instrument can be conveyed along a borehole with the inner tube assembly and operated in the borehole.

[0042] Preferably, the retrieval system comprises an overshot assembly attached to the end of a wireline.

[0043] Preferably, the upper portion of the body is configured for engagement with the overshot assembly in known manner.

[0044] Preferably, the overshot assembly incorporates means operable for controlled positioning of the body within the borehole for operation of the surveying instrument. The controlled positioning provides stable support within the borehole.

[0045] More particularly, said means operable for controlled positioning of the body within the borehole comprises means for controlling positioning of the overshot assembly within the borehole. With this arrangement, it is the controlled positioning of the overshot assembly within the borehole that effectively controls the position of the body within the borehole for operation of the surveying instrument by virtue of the connection between the core tube assembly and the overshot assembly. In other words, controlling the positioning of the overshot assembly within the borehole has the effect of controlling the positioning of the core inner tube assembly, and hence the position of the body of the core inner tube assembly in which the downhole surveying instrument is accommodated.

[0046] The means operable for controlled positioning of the body within the borehole may comprise means for engaging the surrounding portion of a drill string to stabilise the overshot assembly with respect to the drill string.

[0047] The engaging means may be adapted to support the overshot assembly within the surrounding portion of the drill string in a circumferentially centred manner. With such an arrangement, the engaging means may be configured as a centraliser.

[0048] The engaging means may comprise radially disposed arms biased outwardly to contact sides of the drill string, thus centrally positioning the overshot assembly within the surrounding portion of the drill string. The arms may each include an outer contact portion configured for contact with the inner wall of the surrounding portion of the drill string. The outer contact portion may be of any appropriate form, such as a pad or a roller.

[0049] In one arrangement, the engaging means may be configured to engage the drill string for movement therealong as the overshot assembly is raised or lowered within the borehole. With this arrangement, the engaging means may comprise a fixed structure configured as a carriage for movement along the internal wall of the drill string.

[0050] In another arrangement, the engaging means may be adapted for movement between collapsed and extended conditions, whereby in the collapsed condition it is clear of the internal wall of the drill string for movement therealong and in the extended condition it is in engagement with the drill string for controlled positioning of the overshot assembly within the borehole to provide stable support for operation of the surveying instrument.

[0051] According to a third broad aspect of the present invention there is provided an overshot assembly comprising a body having an upper portion adapted for connection to a wireline and a lower portion adapted to be releasably connected to an inner tube assembly, the body being adapted to receive a downhole surveying instrument, whereby the downhole surveying instrument can be conveyed along a borehole with the overshot assembly and operated in the borehole.

[0052] The downhole surveying instrument may comprise a downhole survey tool or a component thereof.

[0053] The downhole surveying instrument may, for example, comprise a downhole tool comprising one or more sensor devices such as orthogonal accelerometers, magnetometers, gyroscopes, MEMS (microelectromechanical) gyro sensors, or any combination thereof.

[0054] A suitable downhole surveying instrument may comprise the downhole tool as described and illustrated in International application PCT/AU2011/000628, the contents of which are incorporated herein by way of reference. Other appropriate downhole tools can, of course, also be used.

[0055] Where the downhole surveying instrument comprises a geo-magnetic device, it may be necessary for the body, or at least relevant parts thereof, to be made of material or materials which do not interfere magnetically with the geo-magnetic device. In particular, the body, or at least relevant parts thereof, may need to be made of material which is non-magnetic.

[0056] Where the downhole surveying instrument does not comprise a geo-magnetic device, the body would not necessarily need to be made of materials which are non-magnetic. The downhole surveying tool described and illustrated in International application PCT/AU2011/000628 is an example of an arrangement in which the body would not necessarily need to be made of materials which are non-magnetic.

[0057] Preferably, the downhole surveying instrument is operable within the borehole while the overshot assembly is connected to the inner tube assembly.

[0058] Preferably, the overshot assembly further comprises means operable for controlled positioning of the body within the borehole for operation of the surveying instrument.

[0059] The controlled positioning provides stable support within the borehole.

[0060] The means operable for controlled positioning of the body within the borehole may comprise means for engaging the surrounding drill string to stabilise the body.

[0061] The engaging means may be adapted to support the body within the drill string in a circumferentially centred manner. With such an arrangement, the engaging means may be configured as a centraliser.

[0062] The engaging means may comprise radially disposed arms biased outwardly to contact sides of the drill string, thus centrally positioning the body within the drill string. The arms may each include an outer contact portion configured for contact with the inner wall of the surrounding drill string. The outer contact portion may be of any appropriate form, such as a pad or a roller.

[0063] In one arrangement, the engaging means may be configured to engage the drill string for movement therealong as the overshot assembly is raised or lowered within the borehole. With this arrangement, the engaging means may comprise a fixed structure configured as a carriage for movement along the internal wall of the drill string.

[0064] In another arrangement, the engaging means may be adapted for movement between collapsed and extended conditions, whereby in the collapsed condition it is clear of the internal wall of the drill string for movement therealong and in the extended condition it is in engagement with the drill string for controlled positioning of the body within the borehole to provide stable support for operation of the surveying instrument.

[0065] The body may incorporate a cavity for accommodating the downhole surveying instrument.

[0066] Preferably, the body is configured to facilitate installation of the downhole surveying instrument in the cavity. The body may, for example, be constructed in two or more parts, with one part being selectively separable from another part to provide access to the cavity.

[0067] Preferably, the body is adapted to provide cushioning to afford some impact protection for the surveying instrument. In particular, the body is preferably configured to cushion impact forces when moving into contact with a downhole inner tube assembly following descent on the wireline.

[0068] The cushioning may be provided by a cushioning mechanism incorporated in the body.

[0069] The cushioning mechanism may comprise an elastic structure such as a spring for absorbing a shock impact. The cushioning mechanism may further comprise a shock absorber for damping the spring oscillations.

[0070] The cushioning mechanism may alternatively, or additionally, comprise a parachute, or other controlled descent system or method.

[0071] The cushioning mechanism may be incorporated within the body between two parts thereof.

[0072] Magnetic braking may be utilised to slow the overshot assembly as it approaches the end of its descent into a borehole. The overshot assembly may for example include at least a portion of a magnetic braking system for slowing the overshot assembly in this manner.

[0073] Preferably, the lower portion of the body incorporates a latching mechanism for releasable connection to a mating formation on the inner tube assembly. Typically, the mating formation is configured as a spear and the latching mechanism comprises latching dogs.

[0074] The body may incorporate an actuator for actuating the latching mechanism to engage/disengage the formation upon engagement between the overshot assembly and the inner core tube.

[0075] Preferably, the overshot assembly is provided with a means for allowing a tool face of the downhole surveying instrument to be transferred to an external surface of the overshot assembly. For example, an external surface of the body of the overshot assembly may include a tool face mark, and one of the body and a pressure barrel of the surveying instrument may include a locating lug which is receivable in a groove in the other of the body and the pressure barrel of the surveying instrument so that the tool face of the instrument can thereby be synchronised with the tool face mark on the external surface of the body. Where the downhole surveying instrument comprises one or more gyroscopes, the tool face of the downhole surveying instrument may comprise a gyro tool face, and the tool face mark on the external surface of the body may comprise a gyro tool face mark.

[0076] The overshot assembly may be provided with a means for allowing the tool face to be adjustably transferred to the inner tube assembly.

[0077] According to a fourth broad aspect of the present invention there is provided an apparatus adapted for connection to an inner tube assembly, the apparatus comprising a body being adapted to receive a downhole surveying instrument, whereby the downhole surveying instrument can be conveyed along a borehole with the inner tube assembly and operated in the borehole.

[0078] The apparatus according to the fourth broad aspect of the present invention may comprise a sub or a drop tool assembly attachable to the inner tube assembly.

[0079] According to a fifth broad aspect of the present invention there is provided a drop tool assembly comprising a body having an upper portion adapted to be releasably connected to a retrieval system and a lower portion adapted to be releasably connected to an inner tube assembly, the body being adapted to receive a downhole surveying instrument, whereby the downhole surveying instrument can be conveyed along a borehole with the drop tool assembly and operated in the borehole.

[0080] Preferably, the retrieval system comprises an overshot assembly attached to the end of a wireline.

[0081] Preferably, the upper portion of the body is configured for engagement with the overshot assembly in known manner.

[0082] Preferably, the drop tool assembly incorporates means operable for controlled positioning of the body within the borehole for operation of the surveying instrument. The controlled positioning provides stable support within the borehole.

[0083] The means operable for controlled positioning of the body within the borehole may comprise means for engaging the surrounding drill string to stabilise the body.

[0084] The engaging means may be adapted to support the body within the drill string in a circumferentially centred manner. With such an arrangement, the engaging means may be configured as a centraliser.

[0085] The engaging means may comprise radially disposed arms biased outwardly to contact sides of the drill string, thus centrally positioning the body within the drill string. The arms may each include an outer contact portion configured for contact with the inner wall of the surrounding drill string. The outer contact portion may be of any appropriate form, such as a pad or a roller.

[0086] In one arrangement, the engaging means may be configured to engage the drill string for movement therealong as the drop tool assembly is raised or lowered within the borehole. With this arrangement, the engaging means may comprise a fixed structure configured as a carriage for movement along the internal wall of the drill string.

[0087] In another arrangement, the engaging means may be adapted for movement between collapsed and extended conditions, whereby in the collapsed condition it is clear of the internal wall of the drill string for movement therealong and in the extended condition it is in engagement with the drill string for controlled positioning of the body within the borehole to provide stable support for operation of the surveying instrument.

[0088] The body may incorporate a cavity for accommodating the downhole surveying instrument.

[0089] Preferably, the body is configured to facilitate installation of the downhole surveying instrument in the cavity. The body may, for example, be constructed in two or more parts, with one part being selectively separable from another part to provide access to the cavity.

[0090] Magnetic braking may be utilised to slow the drop tool assembly as it approaches the end of its descent into a borehole. The drop tool assembly may for example include at least a portion of a magnetic braking system for slowing the drop tool assembly in this manner.

[0091] Preferably, the body has an upper portion adapted to be releasably connected to an overshot assembly, and a lower portion adapted to be releasably connected to an inner tube assembly.

[0092] Preferably, the lower portion of the body incorporates a latching mechanism for releasable connection to a mating formation on the inner tube

assembly. Typically, the mating formation is configured as a spear and the latching mechanism comprises latching dogs.

[0093] The body may incorporate an actuator for actuating the latching mechanism to engage the formation upon engagement between the drop tool assembly and the inner core tube.

[0094] Preferably, the upper portion of the body incorporates a mating formation. It is preferred that the mating formation is configured as a spearhead point.

[0095] The downhole surveying instrument may comprise a downhole survey tool or a component thereof.

[0096] The downhole surveying instrument may, for example, comprise a downhole tool comprising one or more sensor devices such as orthogonal accelerometers, magnetometers, gyroscopes, MEMS (microelectromechanical) gyro sensors, or any combination thereof.

[0097] A suitable downhole surveying instrument may comprise the downhole tool as described and illustrated in International application PCT/AU2011/000628, the contents of which, as mentioned above, are incorporated herein by way of reference. Other appropriate downhole tools can, of course, also be used.

[0098] Where the downhole surveying instrument comprises a geo-magnetic device, it may be necessary for the body, or at least relevant parts thereof, to be made of material or materials which do not interfere magnetically with the geo-magnetic device. In particular, the body or at least relevant parts thereof, may need to be made of material which is non-magnetic.

[0099] Where the downhole surveying instrument does not comprise a geo-magnetic device, the body would not necessarily need to be made of materials which are non-magnetic. The downhole surveying tool described and illustrated in International application PCT/AU2011/000628 is an example of an arrangement in which the body would not necessarily need to be made of materials which are non-magnetic.

[00100] The downhole surveying instrument may be operable within the borehole either while the drop tool assembly is connected to the inner tube assembly, or when the drop tool assembly is not connected to the inner tube assembly.

[00101] Preferably, the drop tool assembly is provided with a means for allowing a tool face of the downhole surveying instrument to be effectively transferred to an external surface of the drop tool assembly. For example, an external surface of the body of the drop tool assembly may include a tool face mark, and one of the body and a pressure barrel of the surveying instrument may include a locating lug which is receivable in a groove in the other of the body and the pressure barrel of the surveying instrument so that the tool face of the instrument can thereby be synchronised with the tool face mark on the external surface of the body. Where the downhole surveying instrument comprises one or more gyroscopes, the tool face of the downhole surveying instrument may comprise a gyro tool face, and the tool face mark on the external surface of the body may comprise a gyro tool face mark.

[00102] The drop tool assembly may be provided with a means for allowing the tool face to be adjustably transferred to the inner tube assembly.

[00103] Preferably, the drop tool assembly also comprises a water pressure activation system for indicating when the drop tool assembly has landed in or otherwise reached its final position within a borehole. It is preferred that the water pressure activation system is operable to activate/deactivate the downhole surveying instrument.

[00104] According to a sixth broad aspect of the present invention there is provided a downhole assembly comprising an inner tube assembly according to the second broad aspect of the present invention in combination with an overshot assembly.

[00105] Preferably, the downhole assembly further comprises a release system for allowing the overshot assembly to be released from the inner tube assembly while the overshot assembly and the inner tube assembly are located downhole.

[00106] Preferably, the downhole assembly also comprises a synchronisation system for allowing the overshot assembly to be connected to the inner tube assembly so that a predetermined tool face of the overshot assembly is synchronised to the inner tube assembly. It is preferred that the predetermined tool face is a predetermined gyro tool face of the overshot assembly.

[00107] Preferably, the synchronisation system comprises a profiled portion of the overshot assembly and a profiled portion of the inner tube assembly, the profiled portions being configured to engage with each other such that the overshot assembly is able to rotate relative to the inner tube assembly into a home position under its own weight or with minimal thrust. It is preferred that each profiled portion comprises a respective mule shoe.

[00108] Preferably, the downhole assembly further comprises a locking system for mechanically locking the inner tube assembly to inturn synchronise to a tool face of the overshot assembly. It is preferred that the locking system comprises a flow clutch.

[00109] Alternatively, in another arrangement, a tool face position of the inner tube assembly is able to be synchronised to the overshot assembly by wireless transmission.

[00110] Preferably the overshot assembly in the combination according to the sixth broad aspect of the present invention comprises means operable for controlled positioning of the body within the borehole for operation of the surveying instrument.

[00111] In this regard, the overshot assembly may incorporate any one or more of the features described above.

[00112] According to a seventh broad aspect of the present invention there is provided a downhole assembly comprising a drop tool assembly according to the fifth broad aspect of the present invention in combination with at least one of an inner tube assembly and an overshot assembly.

[00113] Preferably, the downhole assembly comprises a release system for allowing the drop tool assembly to be released from the inner tube assembly while the drop tool assembly is located down hole.

[00114] Preferably, the downhole assembly also comprises a synchronisation system for allowing the drop tool assembly to be connected to the inner tube assembly so that a predetermined tool face of the drop tool assembly is synchronised to the inner tube assembly. It is preferred that the predetermined tool face is a predetermined gyro tool face of the drop tool assembly.

[00115] Preferably, the synchronisation system comprises a profiled portion of the drop tool assembly and a profiled portion of the inner tube assembly, the profiled portions being configured to engage with each other such that the drop tool assembly is able to rotate relative to the inner tube assembly into a home position under its own weight or with minimal thrust. It is preferred that each profiled portion comprises a respective mule shoe.

[00116] Preferably, the downhole assembly further comprises a locking system for mechanically locking the inner tube assembly to inturn synchronise to a tool face of the drop tool assembly. It is preferred that the locking system comprises a flow clutch.

[00117] Alternatively, in another arrangement, a tool face position of the inner tube assembly is able to be synchronised to the drop tool assembly by wireless transmission.

[00118] According to an eighth broad aspect of the present invention there is provided a method of conducting a borehole surveying operation using a surveying instrument accommodated in an apparatus according to the first broad aspect of the present invention.

[00119] According to a ninth broad aspect of the present invention there is provided a method of conducting a borehole surveying operation using a surveying instrument accommodated in an inner tube assembly according to the second broad aspect of the present invention.

[00120] According to tenth broad aspect of the present invention there is provided a method of conducting a borehole surveying operation using a surveying instrument accommodated in an overshot assembly according to the third broad aspect of the present invention.

[00121] According to an eleventh broad aspect of the present invention there is provided a method of conducting a borehole surveying operation using a surveying instrument accommodated in an apparatus according to the fourth broad aspect of the present invention.

[00122] According to a twelfth broad aspect of the present invention there is provided a method of conducting a borehole surveying operation using a surveying instrument accommodated in a drop tool assembly according to the fifth broad aspect of the present invention.

[00123] According to thirteenth broad aspect of the present invention there is provided a method of conducting a borehole surveying operation using a surveying instrument accommodated in an inner tube assembly forming part of a combination according to the sixth broad aspect of the present invention.

[00124] According to a fourteenth broad aspect of the present invention there is provided a method of conducting a borehole surveying operation using a surveying instrument accommodated in a drop tool assembly forming part of a combination according to the seventh broad aspect of the present invention.

[00125] According to a fifteenth broad aspect of the present invention there is provided a method of conducting a borehole surveying operation using apparatus incorporating an onboard downhole surveying instrument, the method comprising lowering the apparatus down the borehole, taking a measurement down the borehole using the onboard downhole surveying instrument, and retrieving a core sample using the apparatus.

[00126] The method may further comprise actuating the onboard downhole surveying instrument to take the measurement in response to the apparatus approaching or completing the end of its descent into the borehole.

[00127] Typically, the apparatus comprises an overshot assembly.

[00128] According to sixteenth broad aspect of the present invention there is provided a method of conducting a borehole surveying operation using an inner tube assembly incorporating an onboard downhole surveying instrument, the method comprising deploying the inner tube assembly in the borehole, taking a

measurement down the borehole using the onboard downhole surveying instrument, and retrieving the inner tube assembly containing a core sample.

[00129] Preferably, the core inner tube assembly incorporating the onboard downhole surveying instrument is retrieved from the borehole using an overshot assembly.

[00130] Preferably, the method further comprises controlling the position of the core inner tube assembly within the borehole for operation of the surveying instrument.

[00131] Preferably, the act of controlling the position of the core inner tube assembly within the borehole for operation of the surveying instrument comprises controlling the positioning of the overshot assembly within the borehole.

[00132] According to a seventeenth broad aspect of the present invention there is provided a method of conducting a borehole surveying operation using an overshot assembly according to the third broad aspect of the present invention.

[00133] According to an eighteenth broad aspect of the present invention there is provided a method of conducting a borehole surveying operation using an overshot assembly incorporating an onboard downhole surveying instrument, the method comprising lowering the overshot assembly down the borehole, taking a measurement down the borehole using the onboard downhole surveying instrument, and retrieving an inner tube assembly containing a core sample using the overshot assembly.

[00134] According to a nineteenth broad aspect of the present invention there is provided a method of conducting a borehole surveying operation using a drop tool assembly incorporating an onboard downhole surveying instrument, the method comprising lowering the drop tool assembly down the borehole using the onboard downhole surveying instrument, and retrieving an inner tube assembly containing a core sample using the drop tool assembly and an overshot assembly.

[00135] The term "measurement" as used herein is taken to include any reading, data, signal, or other input or collection of inputs received by the downhole surveying instrument.

BRIEF DESCRIPTION OF THE DRAWINGS

[00136] In order that the invention may be more fully understood and put into practice, a preferred embodiment thereof will now be described with reference to the accompanying drawings in which:

Figure 1 is a schematic side view of an inner tube assembly;

Figure 2 is a schematic side view of an overshot assembly for use in combination with the inner tube assembly;

Figure 3 is a fragmentary side view of the bottom end of a drill string incorporating a drill barrel connected to a series of drill rods, with the inner tube assembly being receivable in the drill barrel in known manner;

Figure 4 is a schematic side view of another overshot assembly;

Figure 5 depicts an overshot assembly and an inner tube assembly of a downhole assembly;

Figure 6 depicts a drop tool assembly and an inner tube assembly of a downhole assembly;

Figure 7 depicts a portion of the drop tool assembly body, and a portion of the surveying instrument pressure barrel; and

Figure 8 depicts a water pressure activation system of the drop tool assembly.

DESCRIPTION OF EMBODIMENTS

[00137] In the drawings, like features have been referenced with like reference numbers.

[00138] The preferred embodiment shown in Figures 1 to 3 of the drawings is directed to an inner tube assembly 10 for core retrieval in core drilling operations for borehole surveys. The inner tube assembly 10 is configured to accommodate

an onboard downhole surveying instrument, as will be explained in more detail later. This arrangement allows for coordination between downhole surveying and core retrieval operations in order to reduce downtime while the procedures are being performed,

[00139] The core drilling operation is performed with a core drill comprising an outer tube assembly 13 in conjunction with the inner tube assembly 10. The outer tube assembly 13 is referred to as the drilling barrel and is fitted as a bottom end assembly 15 to a series of drill rods or drill pipes 17 which constitute a drill string.

[00140] The inner tube assembly 10 comprises a body 21 having a bottom end section 23 and a top end section 25. The bottom end section 23 incorporates a core inner tube (not shown) to progressively receive a core sample during a core drilling operation in known manner.

[00141] The top end section 25 incorporates a backend assembly which includes a spearhead point 27 releasably engagable with an overshot assembly 30 in known manner. With this arrangement, the inner tube assembly 10 can be lowered into, and retrieved from, the outer tube assembly 13 and the associated drill string 17.

[00142] The body 21 defines an internal compartment 33 adapted to accommodate a downhole survey instrument 35, as shown in Figure 1. In this way, the downhole survey instrument 35 is onboard the inner tube assembly 10. The downhole survey instrument 35 would typically comprise a downhole tool having one or more sensor devices such as orthogonal accelerometers, magnetometers, gyroscopes, MEMS (microelectromechanical) gyro sensors, or any combination thereof. In this preferred embodiment, the compartment 33 is configured to receive a downhole tool of the type described and illustrated in international application PCT/AU2011/000628, the contents of which are incorporated herein by way of reference.

[00143] The body 21 may incorporate means (not shown) such as an IR port or other telemetry arrangement for communication with the downhole survey instrument to retrieve measurements therefrom.

[00144] The body 21 comprises an upper portion 41 and a lower portion 43 adapted to be releasably connected together by a fluid-tight connection 45. The connection 45 may comprise a threaded connection and an associated fluid seal arrangement. The two portions 41, 43 cooperate to define the internal compartment 33 adapted to receive and accommodate the downhole survey instrument 35. The two portions 41, 43 can be separated by disengaging the connection 45 to provide access to the compartment 33 for insertion and removal of the downhole survey instrument 35.

[00145] The core inner tube assembly 10 can be used with a conventional overshot. Assembly.

[00146] However, it may be advantageous to use the core inner tube assembly 10 in conjunction with an overshot assembly which has a facility to provide controlled positioning of the body 21 of the inner tube assembly 10 within the borehole for operation of the onboard surveying instrument 35. The controlled positioning is intended to provide stable support of the body 21 within the drill string 17 in order to allow the onboard surveying instrument 35 to take measurements which are not affected by movement and vibration.

[00147] The overshot assembly 30 shown in Figure 2 is provided with such a facility to provide controlled positioning of the body 21 within the borehole.

[00148] In the arrangement illustrated in Figure 2, the overshot assembly 30 comprises a body 51 having a lower end section 53 and an upper end section 55.

[00149] The lower end section 53 of the body 51 incorporates a latching mechanism 57 for releasable connection to the spearhead point 27 on the inner tube assembly 10. The latching mechanism 57 may comprise latching dogs of known kind for releasable engagement with the spearhead point 27. The body 51 may also incorporate an actuator (not shown) for actuating the latching mechanism 57 to engage/disengage the spearhead point 27 upon engagement between the overshot assembly 30 and the inner tube assembly 10.

[00150] The upper end section 55 of the body 51 is configured for attachment to a wireline cable 59 of known kind, as shown in Figure 2.

[00151] The overshot assembly 30 further comprises means 60 operable for the above-mentioned controlled positioning of the body 21 of the inner tube assembly 10 within the borehole. More particularly, such means 60 is operable for controlling positioning of the overshot assembly 30 within the borehole. With this arrangement, it is the controlled positioning of the overshot assembly 30 within the borehole that effectively controls the position of the body 21 of the inner tube assembly 10 within the borehole by virtue of the connection between the core tube assembly 10 and the overshot assembly 30. In other words, controlling the positioning of the overshot assembly 30 within the borehole has the effect of controlling the positioning of the core tube assembly 10, and hence the position of the body 21 of the core tube assembly 10 in which the downhole surveying instrument 35 is accommodated.

[00152] The position of the overshot assembly 30 is controlled by controlling the position of the overshot body 51 within the drill string 17. For this purpose, the means 60 comprises engaging means 61 provided on the overshot assembly 30 for engaging the surrounding section of the drill string 17 to stabilise the overshot body 51.

[00153] The engaging means 61 is configured as a centraliser 63 which is adapted to support the body 51 within the drill string 17 in a circumferentially centred manner.

[00154] The centraliser 63 comprises a series of radially disposed arms 65 adapted to extend outwardly to contact sides of the drill rods 17, thus centrally positioning the body 51 within the surrounding section of the drill string. The radially disposed arms 65 are circumferentially spaced. In this preferred embodiment, there are four radially disposed arms although other arrangements may be used.

[00155] The arms 65 each include an outer contact portion 67 configured for contact with the inner wall of the surrounding section of the drill string. The outer contact portion 67 may be of any appropriate form, such as a pad or a roller.

[00156] In the arrangement shown, the arms 65 are adapted for movement between collapsed and extended conditions, whereby in the collapsed condition each arm is clear of the internal wall for the drill rods and in the extended

condition it is in engagement with the drill rods for controlled positioning of the body 51 within the borehole to provide stable support for operation of the surveying instrument 35 onboard the core inner tube assembly 10.

[00157] In operation, the core drill operates in the normal way. A core is generated during the drilling operation, with the core progressively extending along the core inner tube within the inner tube assembly 10 as drilling progresses. When a core sample is required, the core within the core inner tube is fractured to provide the core sample. The inner tube assembly 10 and the fractured core sample contained therein are then retrieved from within the drill hole using the overshot assembly 30 which is lowered down to the inner tube assembly on the wireline cable 59. As the overshot assembly 30 contacts the inner tube assembly 10, the latching mechanism 57 engages the spearhead point 27 on the inner tube assembly.

[00158] Once the overshot assembly 30 has been connected to the inner tube assembly 10, the centraliser 63 can be actuated as desired to support the body 51 within the surrounding section of the drill string 17 in a circumferentially centred manner. This controlled positioning provides stable support for the body 21 of the inner tube assembly 10 within the drill string in order to allow the onboard surveying instrument 35 to take measurements which are not affected by movement and vibration. Once the measurements are taken, the centraliser 63 can be released and the overshot assembly 30 can be raised using the wireline cable 59 to complete the core retrieval process in the conventional manner.

[00159] The surveying instrument 35 onboard the inner tube assembly 10 can be interrogated as required to retrieve recorded data.

[00160] It is a particular feature of the preferred embodiment that the surveying instrument 35 is onboard the inner tube assembly 10, thereby allowing surveying measurements to be taken during the core collection and retrieval process as desired. In other words, the taking of surveying measurements can be integrated with the core collection and retrieval process, rather than being a separate operation as is conventional practice. This is advantageous, as it can reduce the downtime during which drilling operations need to be suspended in order for core samples to be retrieved and surveying measurements to be taken.

[00161] In this preferred embodiment, the downhole instrument 35 comprising the tool of the type described and illustrated in international application PCT/AU2011/000628 is not affected by magnetic materials in the presence of the environment of its use, and so the body can be constructed of any appropriate material; that is, it is not necessary to use non-magnetic materials such as CuBe in the construction of the body 21 of the inner tube assembly 10.

[00162] In other preferred embodiments with which a geo-magnetic device is used as the survey instrument, it may be necessary for the body 21, or at least relevant parts thereof, to be made of material or materials which do not interfere magnetically with the geo-magnetic device. In particular, the body, or at least relevant parts thereof, may need to be to be made of material which is non-magnetic.

[00163] The preferred embodiment shown in Figure 4 of the drawings is directed to an overshot assembly 100 for use in a core drilling operation in a borehole survey.

[00164] The core drilling operation is performed with a core drill (not shown) fitted as a bottom end assembly to a series of drill rods. The core drill comprises an inner tube assembly, which includes a core tube, for core retrieval. The core drill also comprises an outer tube assembly.

[00165] The inner tube assembly further comprises a backend assembly which includes a spearhead point releasably engagable with the overshot assembly 100. In Figure 4, the spearhead point is depicted schematically and identified by reference numeral 101.

[00166] With this arrangement, the inner tube assembly can be lowered into, and retrieved from, the outer tube assembly and the drill string to which the outer tube assembly is incorporated.

[00167] The overshot assembly 100 comprises a body 105 having a lower end 107 and an upper end 109. The body defines an internal compartment 111 adapted to accommodate a downhole survey instrument. In this way, the downhole survey instrument is onboard the overshot assembly 100. The downhole survey instrument would typically comprise a downhole tool having one or more sensor devices such as orthogonal accelerometers,

magnetometers, gyroscopes, MEMS (microelectromechanical) gyro sensors, or any combination thereof. In this preferred embodiment, the compartment 111 is configured to receive a downhole tool of the type described and illustrated in international application PCT/AU2011/000628, the contents of which are incorporated herein by way of reference.

[00168] The body 105 incorporates means 108 such as an IR port or other telemetry method for communication with the downhole survey instrument to retrieve measurements therefrom.

[00169] The body 105 comprises an upper portion 113 and a lower portion 115, with the two portions being interconnected by a cushioning mechanism 117 adapted to provide cushioning to afford some impact protection for the downhole survey instrument accommodated in the compartment 111. In particular, the cushioning mechanism 117 is adapted to cushion impact forces when the overshot assembly 100 descends into contact with the inner tube assembly.

[00170] In the arrangement illustrated in Figure 4, the cushioning mechanism 117 comprises an elastic structure 119 configured as a spring for absorbing a shock impact. The cushioning mechanism 117 further comprises a shock absorber 121 for damping the spring oscillations. The shock absorber 121 may be of any appropriate type, such as an arrangement adapted for controlled displacement of damping fluid (comprising, for example, air and oil) to effect a damping action.

[00171] The compartment 111 is incorporated in the upper portion 113. The upper portion 113 comprises two sections, being a top section 123 and a bottom section 125 adapted to be releasably connected together by fluid-tight connection 127. The connection 127 may comprise a threaded connection and an associated fluid seal arrangement. The two sections 123, 125 cooperate to define the compartment 111 adapted to receive and accommodate the downhole survey instrument. The two sections 123, 125 are selectively separable to provide access to the compartment 111.

[00172] The lower end 107 of the body 105 incorporates a latching mechanism 131 for releasable connection to the spearhead point 101 on the inner tube assembly. In this embodiment, the latching mechanism 131

comprises latching dogs of known kind for releasable engagement with the spearhead point 101.

[00173] The body 105 also incorporates an actuator (not shown) for actuating the latching mechanism 131 to engage/disengage the spearhead point 101 upon engagement between the overshot assembly 100 and the inner tube assembly.

[00174] The upper end 109 of the body 105 is configured for attachment to a wireline cable of known kind. In the arrangement illustrated, the upper end 109 of the body 105 incorporates an eyelet 133 to which the wireline cable can be attached. In Figure 4, the wireline cable is depicted schematically and identified by reference numeral 135.

[00175] The overshot assembly 100 further comprises means 140 operable for controlled positioning of the body 105 within the borehole for operation of the surveying instrument accommodated within the compartment 111. The controlled positioning is intended to provide stable support of the body 105 within the drill string in order to allow the onboard surveying instrument to take measurements which are not affected by movement and vibration.

[00176] The means 140 operable for controlled positioning of the body 105 within the borehole comprise engaging means 141 for engaging the adjacent portion of the drill string to stabilise the body.

[00177] The engaging means 141 is configured as a centraliser 143 which is adapted to support the body 105 within the drill pipe in a circumferentially centred manner.

[00178] The centraliser 143 comprises a series of radially disposed arms 145 adapted to extend outwardly to contact sides of the drill pipe, thus centrally positioning the body within the drill pipe. The radially disposed arms 145 are circumferentially spaced. In this preferred embodiment, there are four radially disposed arms 145, although other arrangements may be used.

[00179] The arms 145 each include an outer contact portion 147 configured for contact with the inner wall of the surrounding drill pipe. The outer contact portion 147 may be of any appropriate form, such as a pad or a roller.

[00180] In this preferred embodiment, the arms 145 are adapted for movement between collapsed and extended conditions, whereby in the collapsed condition each arm is clear of the internal wall for the drill pipe and in the extended condition it is in engagement with the drill pipe for controlled positioning of the body 105 within the borehole to provide stable support for operation of the surveying instrument.

[00181] In operation, the core drill operates in the normal way. A core is generated during the drilling operation, with the core progressively extending along the core inner tube within the inner tube assembly as drilling progresses. When a core sample is required, the core within the core inner tube is fractured. The inner tube assembly and the fractured core sample contained therein are then retrieved from within the drill hole using the overshot assembly 100 which is lowered down to the inner tube assembly on the wireline cable 135. As the overshot assembly 100 contacts the inner tube assembly, the latching mechanism 131 engages the spearhead point 101 on the inner tube assembly. The impact force generated upon the overshot assembly descending into contact with the inner tube assembly is cushioned by the cushioning mechanism 117 as previously explained. Once the overshot assembly 100 has been connected to the inner tube assembly, the centraliser 143 is actuated to support the body 105 within the drill pipe in a circumferentially centred manner. This controlled positioning effects stable support of the body 105 within the drill pipe in order to allow the onboard surveying instrument to take measurements which are not affected by movement and vibration. Once the measurements are taken, the overshot assembly 100 can be raised using the wireline cable 135 to complete the core retrieval process in the conventional manner.

[00182] It is a particular feature of the preferred embodiment that the surveying instrument is onboard the overshot assembly 100, thereby allowing surveying measurements to be taken during the core retrieval process if desired. In other words, the taking of surveying measurements can be integrated with the core retrieval process, rather than being a separate operation as is conventional practice. This is advantageous, as it can reduce the downtime during which drilling operations need to be suspended in order for core samples to be retrieved and surveying measurements to be taken.

[00183] In this preferred embodiment, the downhole tool of the type described and illustrated in international application PCT/AU2011/000628 is not affected by magnetic materials in the presence of the environment of its use and so the body can be constructed of any appropriate material; that is, it is not necessary to use non magnetic materials such as CuBe in the construction of the body 105.

[00184] In other preferred embodiments with which a geo-magnetic device is used as the survey instrument, it may be necessary for the body, or at least relevant parts thereof, to be made of material or materials which do not interfere magnetically with the geo-magnetic device. In particular, the body, or at least relevant parts thereof, may need to be to be made of material which is non-magnetic.

[00185] Referring to Figure 5 there is depicted an overshot assembly 200 and an inner tube assembly 201 of a downhole assembly 202.

[00186] The overshot assembly 200 can be used in a core drilling operation in a borehole survey.

[00187] The core drilling operation is performed with a core drill (not shown) fitted as a bottom end assembly to a series of drill rods or pipes called a drill string. The core drill comprises the inner tube assembly 201, which includes a core tube, for core retrieval. The core drill also comprises an outer tube assembly.

[00188] The inner tube assembly 201 further comprises a backend assembly which includes a spearhead point 101 releasably engagable with the overshot assembly 200.

[00189] With this arrangement, the inner tube assembly 201 can be lowered into, and retrieved from an outer tube assembly and the drill string to which the outer tube assembly is incorporated.

[00190] The overshot assembly 200 comprises a body 105 having a lower end 107 and an upper end 109. The body 105 defines an internal compartment/cavity 111 adapted to accommodate a downhole survey instrument. In this way, the downhole survey instrument would typically comprise a downhole tool having one or more sensor devices such as orthogonal

accelerometers, magnetometers, gyroscopes, MEMS (microelectromechanical) gyro sensors, or any combination thereof. In this preferred embodiment, the compartment 111 is configured to receive a downhole tool of the type described and illustrated in International application PCT/AU2011/000628 whose contents have been incorporated herein by reference.

[00191] Although not depicted in the drawings, the body 105 may incorporate means such as an infrared (IR) port or other telemetry method for communication with the downhole survey instrument to retrieve measurements therefrom.

[00192] The body 105 comrpises an upper portion 113 and a lower portion 115. Although not shown in the drawings, the two portions 113, 115 may be interconnected by a cushioning mechanism adapted to provide cushioning to afford some impact protection for the downhole survey instrument accommodated in the compartment 111. In particular, the cushioning mechanism is adapted to cushion impact forces when the overshot assembly 200 descends into contact with the inner tube assembly 201.

[00193] The cushioning mechanism could, for example, comprise an elastic structure configured as a spring for absorbing a shock impact. The cushioning mechanism may further comprise a shock absorber for damping the spring oscillations. The shock absorber may be of any appropriate type, such as an arrangement adapted for controlled displacement of damping fluid (comprising, for example, air and oil) to effect a damping action.

[00194] The compartment 111 is incorporated in the upper portion 113. The upper portion 113 comprises two sections, being a top section 123 and a bottom section 125 adapted to be releasably connected together by a fluid-tight connection 127. The connection 127 may comprise a threaded connection and an associated fluid seal arrangement. The two sections 123, 125 cooperate to define the compartment 111 adapted to receive and accommodate the downhole survey instrument. The two sections 123, 125 are selectively separable to provide access to the compartment 111.

[00195] The lower end 107 of the body 105 incorporates a latching mechanism 131 for releasable connection to the spearhead point 101 on the inner tube assembly 201. In this preferred embodiment, the latching mechanism

131 comprises latching/lifting dogs 210 of known kind for releasable engagement with the spearhead point 101.

[00196] The body 105 may also incorporate an actuator (not shown) for actuating the latching mechanism 131 to engage/disengage the spearhead point 101 upon engagement between the overshot assembly 200 and the inner tube assembly 201.

[00197] The upper end 109 of the body 105 is configured for attachment to a wireline cable 135 of known kind. In the arrangement illustrated, the upper end 109 of the body 105 incorporates an eyelet 133 to which the wireline cable 135 can be attached.

[00198] The overshot assembly 200 further comprises means 140 operable for controlled positioning of the body 105 within the borehole for operation of the surveying instrument accommodated within the compartment 111. The controlled positioning is intended to provide stable support of the body 105 within the drill string in order to allow the onboard surveying instrument to take measurements which are not affected by movement and vibration.

[00199] The means 140 operable for controlled positioning of the body 105 within the borehole comprises engaging means 141 for engaging the adjacent portion of the drill string to stabilise the body 105.

[00200] The engaging means 141 is configured as a centraliser 143 which is adapted to support the body 105 within the drill pipe in a circumferentially centred manner.

[00201] The centraliser 143 comprises a series of radially disposed arms 145 adapted to extend outwardly to contact sides of the drill pipe, thus centrally positioning the body 105 within the drill pipe. The radially disposed arms 145 are circumferentially spaced. In this preferred embodiment, there are four radially disposed arms 145, although other arrangements may be used.

[00202] The arms 145 each include an outer contact portion 147 configured for contact with the inner wall of the surrounding drill pipe. The outer contact portion 147 may be of any appropriate form, such as a pad or a roller.

[00203] The arms 145 may be adapted for movement between collapsed and extended conditions, whereby in the collapsed condition each arm 145 is clear of the internal wall of the drill pipe and in the extended condition it is in engagement with the drill pipe for controlled positioning of the body 105 within the borehole to provide stable support for operation of the surveying instrument.

[00204] Magnetic braking may be utilised to slow the overshot assembly 200 as it approaches the end of its descent into a borehole. The overshot assembly 200 may for example include at least a portion of a magnetic braking system (not depicted) for slowing the overshot assembly 200 in this manner.

[00205] The overshot assembly 200 is provided with a means 220 for allowing a tool face of the downhole surveying instrument to be transferred to an external surface of the overshot assembly 200. For example, the means 220 may include a tool face mark 221 on an external surface of the body 105, and one of the body 105 and a pressure barrel of the surveying instrument may include a locating lug (not depicted) which is receivable in a groove (not depicted) in the other of the body 105 and the pressure barrel of the surveying instrument when the surveying instrument is inserted into the compartment 111 so that the tool face of the instrument can thereby be synchronised with the tool face mark 221 on the external surface of the body 105. Where the downhole surveying instrument comprises one or more gyroscopes, the tool face of the downhole surveying instrument may comprise a gyro tool face, and the tool face mark 221 on the external surface of the body 105 may comprise a gyro tool face mark.

[00206] The overshot assembly 200 may also be provided with a means 225 for allowing the tool face to be adjustably transferred to the inner tube assembly 201. For example, the means 225 may comprise a shaft (not depicted) which connects the upper portion 113 to the lower portion 115 such that the upper and lower portions 113, 115 are able to be rotated relative to each other. Rotation of the lower portion 115 relative to the upper portion 115 allows the position of a tool face mark 226 on the lower portion 115 to be adjusted relative to the tool face mark 221 and a tool face mark 227 on the inner tube assembly 201. Once the position of the tool face mark 226 has been adjusted, two nuts 228 on the shaft can be tightened to mechanically lock the portions 113, 115 together so as to prevent relative rotation between the portions 113, 115. Where the tool face

mark 221 on the external surface of the body 105 comprises a gyro tool face mark, the tool face marks 226, 227 also comprise gyro tool face marks.

[00207] In the case where the surveying instrument includes one or more gyros which provide the instrument with the ability to reference true North in any aspect/environment, this will provide the ability to orientate core or the bottom hole assembly at vertical inclinations that previously could not be done with accelerometers or magnetic sensors. By being able to detect the Earth's true North direction, this can be reference directly to an external mark (i.e. gyro tool face) on the instrument/tool to give the position of the gyro tool face in relation to true North.

[00208] The downhole assembly 202 further comprises a release system 230 for allowing the overshot assembly 200 to be released from the inner tube assembly 201 while the overshot assembly 200 and the inner tube assembly 201 are located downhole. The release system 230 is operable to disengage the dogs 210 of the latching mechanism 131 from the spearhead point 101.

[00209] Additionally, the downhole assembly 202 comprises a synchronisation system 235 for allowing the overshot assembly 200 to be connected to the inner tube assembly 201 so that a predetermined tool face 221 of the overshot assembly 200 is synchronised to the inner tube assembly 201.

[00210] The synchronisation system 235 comprises a profiled portion 236 of the lower body portion 115 of the overshot assembly 200, and a profiled portion 237 of the inner tube assembly 201. The profiled portion 236 comprises a mule shoe 238, and the profiled portion 237 comprises a mule shoe 239. The profiled portions 236, 237 are configured to engage with each other such that the overshot assembly 200 is able to rotate relative to the inner tube assembly 201 into a home position under its own weight or with only minimal thrust.

[00211] Downhole assembly 202 also comprises a locking system 245 for mechanically locking the inner tube assembly 201 to inturn synchronise to the tool face 221 of the overshot assembly 200. The locking system 245 may comprise a flow clutch which is provided as part of the inner tube assembly 201 and which is able to engage and disengage the connection between two co-linear components of a rock drilling device.

[00212] Rather than including the mechanical locking system 245, the tool face position of the inner tube assembly 201 may be synchronised to the overshot assembly 200 by wireless transmission.

[00213] In operation, the core drill operates in the normal way. A core is generated during the drilling operation, with the core progressively extending along the core inner tube within the Inner tube assembly 201 as drilling progresses. When a core sample is required, the core within the core inner tube is fractured. The inner tube assembly 201 and the fractured core sample contained therein are then retrieved from within the drill hole using the overshot assembly 200 which is lowered down to the inner tube assembly 201 on the wireline cable 135. As the overshot assembly 200 contacts the inner tube assembly 201, the latching mechanism 131 engages the spearhead point 101 on the inner tube assembly 201. The impact force generated upon the overshot assembly 200 descending into contact with the inner tube assembly 201 is cushioned by the cushioning mechanism (if present). Also, if a magnetic braking means is present, the speed of descent of the overshot assembly 200 is slowed as it approaches the inner tube assembly 201. Once the overshot assembly 200 has been connected to the inner tube assembly 201, the centraliser 143 is actuated to support the body 105 within the drill pipe in order to allow the onboard surveying instrument to take measurements which are not affected by movement and vibration. Once the measurements are taken, the overshot assembly 100 can be raised using the wireline cable 135 to complete the core retrieval process in the conventional manner.

[00214] It is a particular feature of the preferred embodiment depicted in Figure 5 that the surveying instrument is onboard the overshot assembly 200, thereby allowing surveying measurements to be taken during the core retrieval process if desired. In other words, the taking of surveying measurements can be integrated with the core retrieval process, rather than being a separate operation as is conventional practice. This is advantageous, as it can reduce the downtime during which drilling operations need to be suspended in order for core samples to be retrieved and surveying measurements to be taken.

[00215] In this preferred embodiment, the downhole tool of the type described and illustrated in International application PCT/AU2011/000628 is not affected by

magnetic materials in the presence of the environment of its use and so the body can be constructed of any appropriate material; that is, it is not necessary to use non-magnetic materials such as CuBe in the construction of the body 105.

[00216] In other embodiments with which a geo-magnetic device is used as the survey instrument, it may be necessary for the body 105, or at least relevant parts thereof, to be made of material or materials which do not interfere magnetically with the geo-magnetic device. In particular, the body, or at least relevant parts thereof, may need to be made of material which is non-magnetic.

[00217] Referring to Figure 6 there is depicted a drop tool assembly 250 and an inner tube assembly 201 of a downhole assembly 252.

[00218] The drop tool assembly 250 may be used in a core drilling operation in a borehole survey in which case the drop tool assembly 250 may be releasably attached to the inner tube assembly 201.

[00219] The drop tool assembly 250 comprises a body/barrel 255 having a lower end 257 and an upper end 259. The body 255 defines an internal compartment/cavity 261 adapted to accommodate a downhole survey instrument. In this way, the downhole survey instrument would typically comprise a downhole tool having one or more sensor devices such as orthogonal accelerometers, magnetometers, gyroscopes, MEMS (microelectromechanical) gyro sensors, or any combination thereof. In this preferred embodiment, the compartment 261 is configured to receive a downhole tool of the type described and illustrated in International application PCT/AU2011/000628 whose contents have been incorporated herein by reference.

[00220] The body 255 incorporates means such as an infrared (IR) port 262 or other telemetry method for communication with the downhole survey instrument to retrieve measurements therefrom.

[00221] The body 255 comprises an upper portion 263 and a lower portion 265. Although not shown in the drawings, the two portions 263, 265 may be interconnected by a cushioning mechanism adapted to provide cushioning to afford some impact protection for the downhole survey instrument accommodated in the compartment 261. In particular, the cushioning

mechanism is adapted to cushion impact forces when the drop tool assembly 250 descends into contact with the inner tube assembly 201.

[00222] The cushioning mechanism could, for example, comprise an elastic structure configured as a spring for absorbing a shock impact. The cushioning mechanism may further comprise a shock absorber for damping the spring oscillations. The shock absorber may be of any appropriate type, such as an arrangement adapted for controlled displacement of damping fluid (comprising for example, air and oil) to effect damping action.

[00223] The compartment 261 is incorporated in the upper portion 263. The upper portion 263 comprises two sections, being a top section 273 and a bottom section 275 adapted to be releasably connected together by a fluid-tight connection 277. The connection 277 may comprise a threaded connection and an associated fluid seal arrangement. The two sections 273, 275 are selectively separable to provide access to the compartment 261.

[00224] The lower end 257 of the body 255 incorporates a latching mechanism 281 for releasable connection to the spearhead point 101 on the inner tube assembly 201. In this preferred embodiment, the latching mechanism 281 comprises latching/lifting dogs 282 of known kind for releasable engagement with the spearhead point 101.

[00225] The body 255 may also incorporate an actuator (not shown) for actuating the latching mechanism 281 to engage/disengage the spearhead point 101 upon engagement between the drop tool assembly 250 and the inner tube assembly 201.

[00226] The upper end 259 of the body 255 incorporates a mating formation 283 which is configured as a spearhead point 284 which is releasably engagable with an overshot assembly (not depicted) which may also be part of the downhole assembly 251. The overshot assembly could be of any known type, it could even be one of the previously described overshot assemblies.

[00227] The drop tool assembly 250 further comprises means 290 operable for controlled positioning of the body 255 within the borehole for operaton of the surveying instrument accommodated within the compartment 261. The controlled positioning is intended to provide stable support of the body 255 within

the drill string in order to allow the onboard surveying instrument to take measurements which are not affected by movement and vibration.

[00228] The means 290 operable for controlled positioning of the body 255 within the borehole comprises engaging means 291 for engaging the adjacent portion of the drill string to stabilise the body 255.

[00229] The engaging means 291 is configured as a centraliser 293 which is adapted to support the body 255 within the drill pipe in a circumferentially centred manner.

[00230] The centraliser 293 comprises a series of radially disposed arms 295 adapted to extend outwardly to contact sides of the drill pipe, thus centrally positioning the body 255 within the drill pipe. The radially disposed arms 295 are circumferentially spaced. In this preferred embodiment, there are four radially disposed arms 295, although other arrangements may be used.

[00231] The arms 295 each include an outer contact portion 297 configured for contact with the inner wall of the surrounding drill pipe. The outer contact portion 297 may be of any appropriate form, such as a pad or a roller.

[00232] The arms 295 may be adapted for movement between collapsed and extended conditions, whereby in the collapsed condition each arm 295 is clear of the internal wall of the drill pipe and in the extended condition it is in engagement with the drill pipe for controlled positioning of the body 255 within the borehole to provide stable support for operation of the surveying instrument.

[00233] Magnetic braking may be utilised to slow the drop tool assembly 250 as it approaches the end of its descent into a borehole. The drop tool assembly 250 may for example include at least a portion of a magnetic braking system (not depicted) for slowing the drop tool assembly 250 in this manner.

[00234] The drop tool assembly 250 is provided with a means 300 for allowing a tool face of the downhole surveying instrument to be transferred to an external surface of the drop tool assembly 250. For example, the means 300 may include a tool face mark 301 on an external surface of the body 255, and one of the body 255 and a pressure barrel 302 (see Figure 7) of the surveying instrument may include a locating lug 303 which is receivable in a groove 304 in the other of the

body 255 and the pressure barrel 302 of the surveying instrument when the surveying instrument is inserted into the compartment 261 so that a tool face 305 of the instrument can thereby be synchronised with the tool face mark 301 on the external surface of the body 255. When the downhole surveying instrument comprises one or more gyroscopes, the tool face of the downhole surveying instrument may comprise a gyro tool face, and the tool face mark 301 on the external surface of the body 255 may comprise a gyro tool face mark.

[00235] The drop tool assembly may also be provided with a means 315 for allowing the tool face to be adjustably transferred to the inner tube assembly 201. For example, the means 315 may comprise a shaft (not depicted) which connects the upper portion 263 to the lower portion 265 such that the upper and lower portions 263, 265 are able to be rotated relative to each other. Rotation of the lower portion 265 relative to the upper portion 263 allows the position of a tool face mark 316 on the lower portion 265 to be adjusted relative to the tool face mark 301 and a tool face mark 227 on the inner tube assembly 201. Once the position of the tool face mark 316 has been adjusted, two nuts 318 on the shaft can be tightened to mechanically lock the portions 263, 265 together so as to prevent relative rotation between the portions 263, 265. Where the tool face mark 301 on the external surface of the body 255 comprises a gyro tool face mark, the tool face marks 316, 227 also comprise gyro tool face marks.

[00236] The downhole assembly 251 further comprises a release system 320 for allowing the drop tool assembly 250 to be released from the inner tube assembly 201 while the drop tool assembly 250 and the inner tube assembly 201 are located downhole. The release system 320 is operable to disengage the dogs 282 of the latching mechanism 281 from the spearhead point 101.

[00237] Additionally, the downhole assembly 251 comprises a synchronisation system 325 for allowing the drop tool assembly 250 to be connected to the inner tube assembly 201 so that a predetermined tool face 301 of the drop tool assembly 250 is synchronised to the inner tube assembly 201.

[00238] The synchronisation system 325 comprises a profiled portion 326 of the lower body portion 265 of the drop tool assembly 250, and a profiled portion 327 of the inner tube assembly 201. The profiled portion 326 comprises a mule shoe 328, and the profiled portion 327 comprises a mule shoe 329. The profiled

portions 326, 327 are configured to engage with each other such that the drop tool assembly 250 is able to rotate relative to the inner tube assembly 201 into a home position under its own weight or with only minimal thrust.

[00239] Downhole assembly 251 also comprises a locking system 245 for mechanically locking the inner tube assembly 201 to inturn synchronise to the tool face 301 of the drop tool assembly 250. The locking system 245 may comprise a flow clutch which is provided as part of the inner tube assembly 201 and which is able to engage and disengage the connection between two co-linear components of a rock drilling device.

[00240] Rather than including the mechanical locking system 245, the tool face position of the inner tube assembly 201 may be synchronised to the drop tool assembly 250 by wireless transmission.

[00241] The drop tool assembly 250 also includes a water pressure activation system 330 for indicating when the drop tool assembly 250 has landed in or otherwise reached its final position within a borehole. The water pressure activation system 330 is operable to activate/deactiveate the downhole surveying instrument. With reference to Figure 8, the water pressure activation system 330 comprises a ball 331 that will indicate a spike in fluid pressure when pumped through a plastic tube 332 once landed. In addition, it includes a V packer 333, and fluid ports 334. Similar water pressure activation systems are known in the art, consequently the system 330 will not be further described here.

[00242] The drop tool assembly 250 and the inner tube assembly 201 may be picked up by an overshot assembly at the same time. There is the options of only using the drop tool assembly 250 to take a borehole survey when such a survey is required as it may be that a gyro survey is not required each time a core sample is obtained. In such a situation, the drop tool assembly 250 may not be attached to the inner tube assembly 201.

[00243] It should be appreciated that the scope of the invention is not limited to the scope of the preferred embodiments described.

[00244] Further, modifications and improvements can be made without affecting the scope of the invention.

[00245] Throughout this specification, unless the context requires otherwise, the word "comprise" or variations such as "comprises" or "comprising", will be understood to imply the inclusion of a stated integer or group of integers but not the exclusion of any other integer or group of integers.

CLAIMS:

1. Apparatus for use in a downhole survey in conjunction with core sampling, the apparatus comprising a body adapted to receive a downhole surveying instrument, whereby the downhole surveying instrument can be conveyed along a borehole with the apparatus and operated in the borehole.

2. The apparatus defined by claim 1, wherein the downhole surveying instrument comprises a downhole survey tool or a component thereof.

3. The apparatus defined by claim 2, wherein the downhole tool comprises one or more sensor devices selected from a group of sensor devices comprising an: orthogonal accelerometer; magnetometer; gyroscope; and a MEMS (microelectromechanical) gyro sensor.

4. The apparatus defined by any one of the preceding claims, wherein the body, or at least relevant parts thereof, are made of material or materials which do not interfere magnetically with downhole surveying instrument.

5. The apparatus defined by claim 4, wherein the body, or at least relevant parts thereof, are made of material which is non-magnetic.

6. The apparatus defined by any one of the preceding claims, wherein the body incorporates a cavity for accommodating the downhole surveying instrument.

7. The apparatus defined by any one of the preceding claims, wherein the body is configured to facilitate installation of the downhole surveying instrument in the cavity.

8. The apparatus defined by claim 7, wherein the body is constructed in two or more parts, with one part being selectively separable from another part to provide access to the cavity.

9. The apparatus defined by any one of the preceding claims, wherein the body is adapted to provide cushioning to afford some impact protection for the surveying instrument.

10. The apparatus defined by claim 9, wherein the body is configured to cushion impact forces following descent into a borehole.

11. The apparatus defined by claim 9 or 10, whrein the cushioning is provided by a cushioning mechanism incorporated in the body.

12. The apparatus defined by claim 11, wherein the cushioning mechanism comprises an elastic structure for absorbing a shock impact.

13. The apparatus defined by claim 12, wherein the elastic structure comprises a spring.

14. The apparatus defined by claim 12 or 13, wherein the cushioning mechanism further comprises a shock absorber for damping the spring oscillations.

15. The apparatus defined by any one of the preceding claims, wherein the apparatus further comprises at least a portion of a magnetic braking system.

16. The apparatus defined by any one of the preceding claims, wherein the apparatus further comprises provision for controlled positioning thereof within the borehole for operation of the surveying instrument.

17. The apparatus defined by claim 16, wherein the provision for controlled positioning within the borehole for operaton of the surveying instrument comprises means for engaging the surrounding portion of a drill string to provide stabilization with respect to the drill string.

18. The apparatus defined by claim 17, wherein the engaging means may be adapted to support the apparatus within the surrounding portion of the drill string in a circumferentially entred manner.

19. The apparatus defined by 18, wherein the engaging means comprises radially disposed arms biased outwardly to contact sides of the drill string, thus centrally positioning the apparatus within the surrounding portion of the drill string.

20. The apparatus defined by claim 19, wherein the arms each include an outer contact portion configured for contact with the inner wall of the surrounding portion of the drill string.

21. The apparatus defined by any one of claims 17 to 20, wherein the engaging means is configured to engage the drill string for movement therealong as the apparatus is raised or lowered within the borehole.

22. The apparatus defined by any one of claims 17 to 20, wherein the engaging means is adapted for movement between collapsed and extended conditions, wherey in the collapsed condition it is clear of the internal wall of the drill string for movement therealong and in the extended condition it is in engagement with the drill string for controlled positioning of the apparatus within the borehole to provide stable support for operation of the surveying instrument.

23. The apparatus defined by any one of claims 17 to 22, wherein the apparatus further comprises actuation means for actuating the engaging means.

24. The apparatus defined by any one of the preceding claims, wherein the apparatus is adapted to initiate operation of the downhole surveying instrument.

25. The apparatus defined by any one of the preceding claims, wherein the apparatus is selected from a group of apparatus comprising: an inner tube assembly of a core drill; an overshot assembly; or an arrangement such as a sub or a drop tool assembly adapted for attachment to an inner tube assembly and/or to an overshot assembly.

26. An inner tube assembly comprising a body having an upper portion adapted for connection to a retrieval system and a lower portion adapted to receive a core sample during a drilling operation, the body being adapted to receive a downhole surveying instrument, whereby the downhole surveying instrument can be conveyed along a borehole with the inner tube assembly and operated in the borehole.

27. The inner tube assembly defined by claim 26, wherein the retrieval system comprises an overshot assembly attached to the end of a wireline.

28. The inner tube assembly defined by claim 26 or 27, wherein the overshot assembly incorporates means operable for controlled positioning of the body within the borehole for operation of the surveying instrument.

29. The inner tube assembly defined by claim 28, wherein the means operable for controlled positioning of the body within the borehole comprises means for controlling positioning of the overshot assembly within the borehole.

30. The inner tube assembly defined by claim 29, wherein the means operable for controlled positioning of the body within the borehole comprises means for engaging the surrounding portion of a drill string to stabilise the overshot assembly with respect to the drill string.

31. The inner tube assembly defined by claim 30, wherein the engaging means is adapted to support the overshot assembly within the surrounding portion of the drill string in a circumferentially centred manner.

32. The inner tube assembly defined by claim 30 or 31, wherein the engaging means comprises radially disposed arms biased outwardly to contact sides of the drill string, thus centrally positioning the overshot assembly within the surrounding portion of the drill string.

33. The inner tube assembly defined by claim 32, wherein the arms each include an outer contact portion configured for contact with the inner wall of the surrounding portion of the drill string.

34. The inner tube assembly defined by any one of claims 30 to 33, wherein the engaging means is configured to engage the drill string for movement therealong as the overshot assembly is raised or lowered within the borehole.

35. The inner tube assembly defined by claim 34, wherein the engaging means comprises a fixed structure configured as a carriage for movement along the internal wall of the drill string.

36. The inner tube assembly defined by any one of claims 30 to 33, wherein the engaging means is adapted for movement between collapsed and extended conditions, whereby in the collapsed condition it is clear of the internal wall of the drill string for movement therealong and in the extended condition it is in engagement with the drill string for controlled positioning of the overshot assembly within the borehole to provide stable support for operation of the surveying instrument.

37. An overshot assembly comprising a body having an upper portion adapted for connection to a wireline and a lower portion adapted to be releasably connected to an inner tube assembly, the body being adapted to receive a downhole surveying instrument, whereby the downhole surveying instrument can be conveyed along a borehole with the overshot assembly and operated in the borehole.

38. The overshot assembly defined by claim 37, wherein the downhole surveying instrument comprises a downhole survey tool or a component thereof.

39. The overshot assembly defined by claim 38, wherein the downhole tool comprises one or more sensor devices selected from a group of sensor devices comprising an orthogonal accelerometer; magnetometer; gyroscope; and a MEMS (microelectromechanical) gyro sensor.

40. The overshot assembly defined by any one of claims 37 to 39, wherein the body, or at least relevant parts thereof, are made of material or materials which do not interfere magnetically with downhole surveying instrument.

41. The overshot assembly defined by claim 40, wherein the body, or at least relevant parts thereof, are made of material which is non-magnetic.

42. The overshot assembly defined by any one of claims 37 to 41 wherein the downhole surveying instrument is operable within the borehole while the overshot assembly is connected to the inner tube assembly.

43. The overshot assembly defined by any one of claims 37 to 42 further comprising means operable for controlled positioning of the body within the borehole for operation of the surveying instrument.

44. The overshot assembly defined by claim 43 wherein the means operable for controlled positioning of the body within the borehole comprises means for engaging the surrounding drill string to stabilise the body.

45. The overshot assembly defined by claim 44 wherein the engaging means is adapted to support the body within the drill string in a circumferentially centred manner.

46. The overshot assembly defined by claim 45 wherein the engaging means is configured as a centraliser.

47. The overshot assembly defined by claims 45 or 46, wherein the engaging means comprise radially disposed arms biased outwardly to contact sides of the drill string, thus centrally positioning the body within the drill string.

48. The overshot assembly defined by claim 47, wherein the arms each include an outer contact portion configured for contact with the inner wall of the surrounding drill string.

49. The overshot assembly defined by any one of claims 44 to 48, wherein the engaging means is configured to engage the drill string for movement therealong as the overeshot assembly is raised or lowered within the borehole

50. The overshot assembly defined by claim 49, wherein the engaging means comprises a fixed structure configured as a carriage for movement along the internal wall of the drill string.

51. The overshot assembly defined by any one of claims 44 to 48, wherein the engaging means is adapted for movement between collapsed and extended conditions, whereby in the collapsed condition it is clear of the internal wall of the drill string for movement therealong and in the extended condition it is in engagement with the drill string for controlled positioning of the body within the borehole to provide stable support for operation of the survey instrument.

52. The overshot assembly defined by any one of claims 37 to 51, wherein the body incorporates a cavity for accommodating the downhole instrument.

53. The overshot assembly defined by claim 52, wherein the body is configured to facilitate installation of the downhole surveying instrument in the cavity.

54. The overshot assembly defined by claim 53, wherein the body comprises two or more parts, with one part being selectively separable from another part to provide access to the compartment.

55. The overshot assembly defined by any one of claims 37 to 54 ,wherein the body is adapted to provide cushioning to afford some impact protection for the surveying instrument.

56. The overshot assembly defined by claim 55, wherein the body is configured to cushion impact forces when moving into contact with a downhole inner tube assembly following descent on the wireline.

57. The overshot assembly defined by claim 55 or 56, wherein the cushioning is provided by a cushioning mechanism incorporated in the body.

58. The overshot assembly defined by claim 57, wherein the cushioning mechanism comprises an elastic structure for absorbing a shock impact.

59. The overshot assembly defined by claim 58, wherein the elastic structure comprises a spring.

60. The overshot assembly defined by claim 58 or 59, wherein the cushioning mechanism further comprises a shock absorber for damping spring oscillations.

61. The overshot assembly according to any one of claims 57 to 60, wherein the cushioning mechanism comprises a parachute or other controlled descent system or method.

62. The overshot assembly defined by any one of claims 57 to 61, wherein the cushioning mechanism is incorporated within the body between two parts thereof.

63. The overshot assembly defined by any one of claims 37 to 62, wherein the overshot assembly further comprises at least a portion of a magnetic braking system for slowing the overshot assembly.

64. The overshot assembly defined by any one of claims 37 to 63, wherein the lower portion of the body incorporates a latching mechanism for releasable connection to a mating formation on the inner core tube assembly.

65. The overshot assembly defined by claim 64, wherein the body incorporates an actuator for actuating the latching mechanism to engage/disengage the formation upon engagement between the overshot assembly and the inner core tube assembly.

66. The overshot assembly defined by any one of claims 37 to 65, wherein the overshot assembly is provided with a means for allowing a tool face of the downhole surveying instrument to be transferred to an external surface of the overshot assembly.

67. The overshot assembly defined by claim 66, wherein the overshot assembly is provided with a means for allowing the tool face to be transferred to the inner tube assembly.

68. Apparatus adapted for connection to an inner tube assembly, the apparatus comprising a body being adapted to receive a downhole surveying instrument, whereby the downhole surveying instrument can be conveyed along a borehole with the inner tube assembly and operated in the borehole.

69. A drop tool assembly comprising a body having an upper portion adapted to be releasably connected to a retrieval system and a lower portion adapted to be releasably connected to an inner tube assembly, the body being adapted to receive a downhole surveying instrument, whereby the downhole surveying instrument can be conveyed along a borehole with the drop tool assembly and operated in the borehole.

70. The drop tool assembly defined by claim 69, wherein the retrieval system comprises an overshot assembly attached to the end of a wireline.

71. The drop tool assembly defined by claim 69 or 70, wherein the drop tool assembly incorporates means operable for controlled positioning of the body within the borehole for operation of the surveying instrument.

72. The drop tool assembly defined by claim 71, wherein the means operable for controlled positioning of the body within the borehole may comprises means for engaging the surrounding drill string to stabilise the body.

73. The drop tool assembly defined by claim 72, wherein the engaging means is adapted to support the body within the drill string in a circumferentially centred manner.

74. The drop tool assembly defined by claim 73, wherein the engaging means is configured as a centraliser.

75. The drop tool assembly defined by any one of claims 72 to 74, wherein the engaging means comprises radially disposed arms biased outwardly to contact sides of the drill string, thus centrally positioning the body within the drill string.

76. The drop tool assembly defined by claim 75, wherein the arms each include an outer contact portion configured for contact with the inner wall of the surrounding drill string.

77. The drop tool assembly defined by any one of claims 72 to 76, wherein the engaging means is configured to engage the drill string for movement therealong as the drop tool assembly is raised or lowered within the borehole.

78. The drop tool assembly defined by claim 77, wherein the engaging means comprises a fixed structure configured as a carriage for movement along the internal was of the drill string.

79. The drop tool assembly defined by any one of claims 72 to 76, wherein the engaging means is adapted for movement between collapsed and extended conditions, whereby in the collapsed condition it is clear of the internal wall of the drill string for movement therealong and in the extended condition it is in engagement with the drill string for controlled positioning of the body within the borehole to provide stable support for operation of the surveying instrument.

80. The drop tool assembly defined by any one of claims 69 to 79, wherein the body incorporates a cavity for accommodating the downhole surveying instrument.

81. The drop tool assembly defined by claim 80, wherein the body is configured to facilitate installation of the downhole surveying instrument in the cavity.

82. The drop tool assembly defined by claim 81, wherein the body is constructed in two or more parts, with one part being selectively separable from another part to provide access to the cavity.

83. The drop tool assembly defined by any one of claims 69 to 82, wherein the drop tool assembly further comprises at least a portion of a magnetic braking system.

84. The drop tool assembly defined by any one of claims 69 to 83, wherein the body has an upper portion adapted to be releasably connected to an overshot assembly, and a lower portion adapted to be releasably connected to an inner tube assembly.

85. The drop tool assembly defined by claim 84, wherein the lower portion of the body incorporates a latching mechanism for releasable connection to a mating formation on the inner tube assembly.

86. The drop tool assembly defined by claim 85, wherein the body incorporates an actuator for actuating the latching mechanism to engage the formation upon engagement between the drop tool assembly and the inner core tube.

87. The drop tool assembly defined by any one of claims 84 to 86, wherein the upper portion of the body incorporates a mating formation.

88. The drop tool assembly defined by any one of claims 69 to 87, wherein the downhole surveying instrument comprises a downhole surveying tool or a component thereof.

89. The drop tool assembly defined by claim 88, wherein the downhole tool comprises one or more sensor devices selected from a group of sensor devices comprising an: orthogonal accelerometer; magnetometer; gyroscope; and a MEMS (microelectromechanical) gyro sensor.

90. The drop tool assembly defined by any one of claims 69 to 89, wherein the body, or at least relevant parts thereof, is made of material or materials which do not interfere magnetically with the geo-magnetic device.

91. The drop tool assembly defined by claim 90, wherein the body or at least relevant parts thereof are made of material which is non-magnetic.

92. The drop tool assembly defined by any one of claims 69 to 91, wherein the downhole surveying instrument is operable within the borehole either while the drop tool assembly is connected to the inner tube assembly, or when the drop tool assembly is not connected to the inner tube assembly.

93. The drop tool assembly defined by any one of claims 69 to 92, wherein the drop tool assembly is provided with a means for allowing a tool face of the downhole surveying instrument to be effectively transferred to an external surface of the drop tool assembly.

94. The drop tool assembly defined by claim 93, wherein the drop tool assembly is provided with a means for allowing the tool face to be adjustably transferred to the inner tube assembly.

95. The drop tool assembly defined by any one of claims 69 to 92, wherein the drop tool assembly also comprises a water pressure activation system for indicating when the drop tool assembly has landed or otherwise reached its final position within a borehole.

96. The drop tool assembly defined by claim 95, wherein the water pressure activation system is operable to activate/deactivate the downhole surveying instrument.

97. A downhole assembly comprising an inner tube assembly according to any one of claims 26 to 36 in combination with an overshot assembly.

98. The downhole assembly defined by claim 97, wherein the downhole assembly further comprises a release system for allowing the overshot assembly to be released from the inner tube assembly while the overshot assembly and the inner tube assembly are located downhole.

99. The downhole assembly defined by claim 97 or 98, wherein the downhole assembly also comprises a synchronisation system for allowing the overshot assembly to be connected to the inner tube assembly so that a predetermined tool face of the overshot assembly is synchronised to the inner tube assembly.

100. The downhole assembly defined by claim 99, wherein the synchronisation system comprises a profiled portion of the overshot assembly and a profiled portion of the inner tube assembly, the profiled portions being configured to engage with each other such that the overshot assembly is able to rotate relative to the inner tube assembly into a home position under its own weight or with minimal thrust.

101. The downhole assembly defined by claim 100, wherein each profiled portion comprises a respective mule shoe.

102. The downhole assembly defined by any one of claims 97 to 101, whrein the downhole assembly further comprises a locking system for mechanically locking the inner tube assembly to inturn synchronise to a tool face of the overshot assembly.

103. The downhole assembly defined by claim 102, wherein the locking system comprises a flow clutch.

104. The downhole assembly defined by any one of claims 97 to 101, wherein a tool face position of the inner tube assembly is able to be synchronised to the overshot assembly by wireless transmission.

105. The downhole assembly defined by any one of claim 97 to 104, wherein the overshot assembly comprises means operable for controlled positioning of the body within the borehole for operation of the surveying instrument.

106. A downhole assembly comprising a drop tool assembly defined by any one of claims 69 to 96 in combination with at least one of an inner tube assembly and an overshot assembly.

107. The downhole assembly defined by claim 106, wherein the downhole assembly also comprises a release system for allowing the drop tool assembly to be released form the inner tube assembly while the drop tool assembly is located down hole.

108. The downhole assembly defined by claim 106 or 107, wherein the downhole assembly also comprises a synchronisation system for allowing the drop tool assembly to be connected to the inner tube assembly so that a predetermined tool face of the drop tool assembly is synchronised to the inner tube assembly.

109. The downhole assembly defined by claim 108, wherein the synchronisation system comprises a profiled portion of the drop tool assembly and a profiled portion of the inner tube assembly, the profiled portions being configured to engage with each other such that the drop tool assembly is able to

rotate relative to the inner tube assembly into a home position under its own weight or with minimal thrust.

110. The downhole assembly defined by claim 109, wherein each profiled portion comprises a respective mule shoe.

111. The downhole assembly defined by any one of claims 106 to 110, wherein the downhole assembly further comprises a locking system for mechanically locking the inner tube assembly to inturn synchronise to a tool face of the drop tool assembly.

112. The downhole assembly defined by claim 111, wherein the locking system comprises a flow clutch.

113. The downhole assembly defined by any one of claims 106 to 110, wherein a tool face position of the inner tube assembly is able to be synchronised to the drop tool assembly by wireless transmission.

114. A method of conducting a borehole surveying operation using a surveying instrument accommodated in an apparatus defined by any one of claims 1 to 25.

115. A method of conducting a borehole surveying operation using a surveying instrument accommodated in an inner tube assembly defined by any one of claims 26 to 36.

116. A method of conducting a borehole surveying operation using a surveying instrument accommodated in an overshot assembly defined by any one of claims 37 to 67.

117. A method of conducting a borehole surveying operation using a surveying instrument accommodated in an apparatus defined by claim 68.

118. A method of conducting a borehole surveying operation using a surveying instrument accommodated in a drop tool assembly defined by any one of claims 69 to 96.

119. A method of conducting a borehole surveying operation using a surveying instrument accommodated in an inner tube assembly forming part of a combination defined by any one of claim 97 to 105.

120. A method of conducting a borehole surveying operation using a surveying instrument accommodated in a drop tool assembly forming part of a combination defined by any one of claims 106 to 113.

121. A method of conducting a borehole surveying operation using apparatus incorporating an onboard downhole surveying instrument, the method comprising lowering the apparatus down the borehole, taking a measurement down the borehole using the onboard downhole surveying instrument, and retrieving a core sample using the apparatus.

122. A method of conducting a borehole surveying operation using an inner tube assembly incorporating an onboard downhole surveying instrument, the method comprising deploying the inner tube assembly in the borehole, taking a measurement down the borehole using the onboard downhole surveying instrument, and retrieving the inner tube assembly containing a core sample.

123. A method of conducting a borehole surveying operation using an overshot defined by any one of claims 37 to 67.

124. A method of conducting a borehole surveying operation using an overshot assembly incorporating an onboard downhole surveying instrument, the method comprising lowering the overshot assembly down the borehole, taking a measurement down the borehole using the onboard downhole surveying instrument, and retrieving an inner tube assembly containing a core sample using the overshot assembly.

125. A method of conducting a borehole surveying operation using a drop tool assembly incorporating an onboard downhole surveying instrument, the method comprising lowering the drop tool assembly down the borehole using the onboard downhole surveying instrument, and retrieving an inner tube assembly containing a core sample using the drop tool assembly and an overshot assembly.

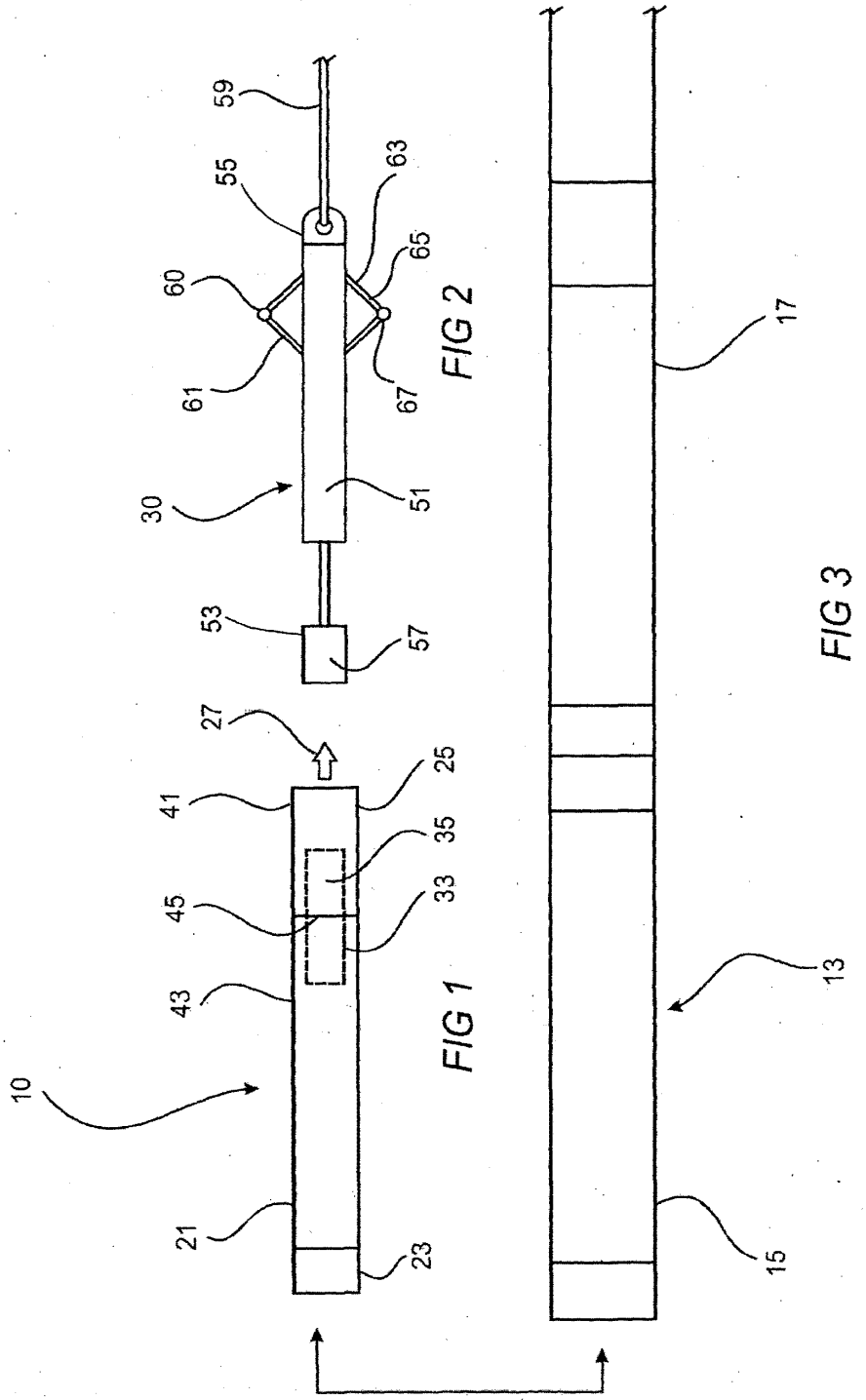


FIG 1

FIG 2

FIG 3

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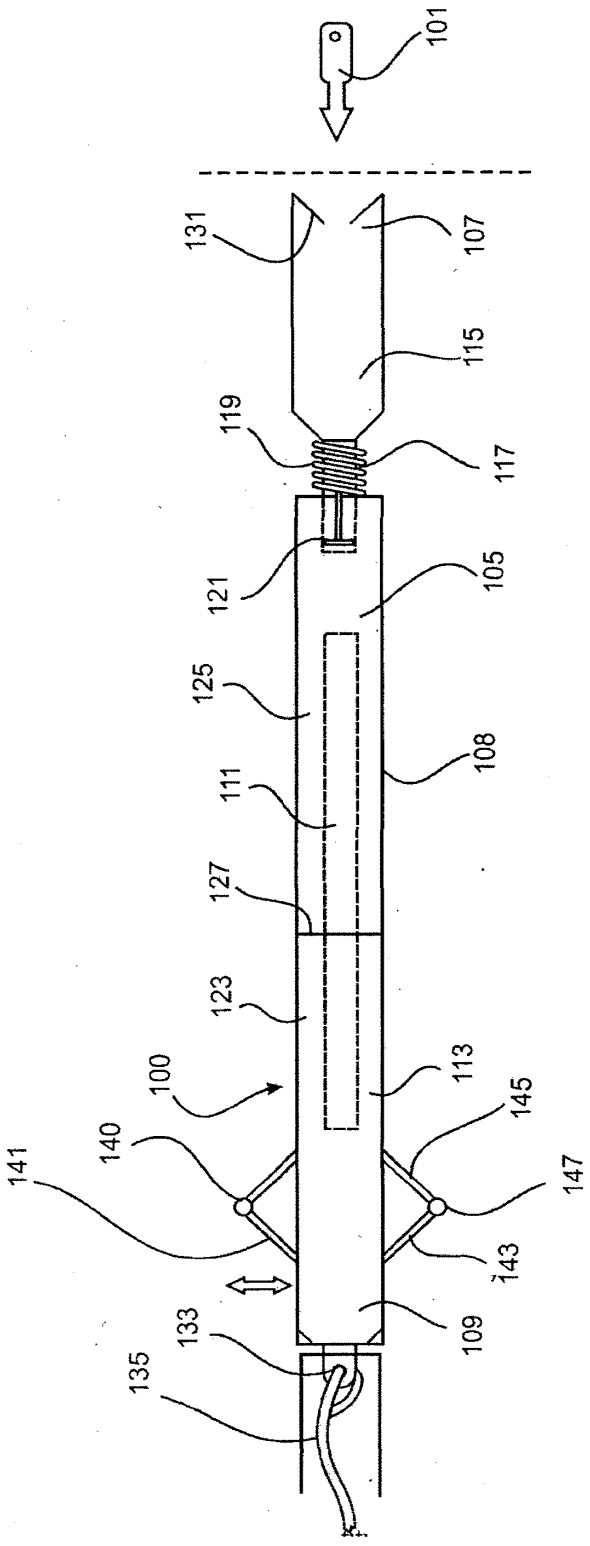


FIG 4

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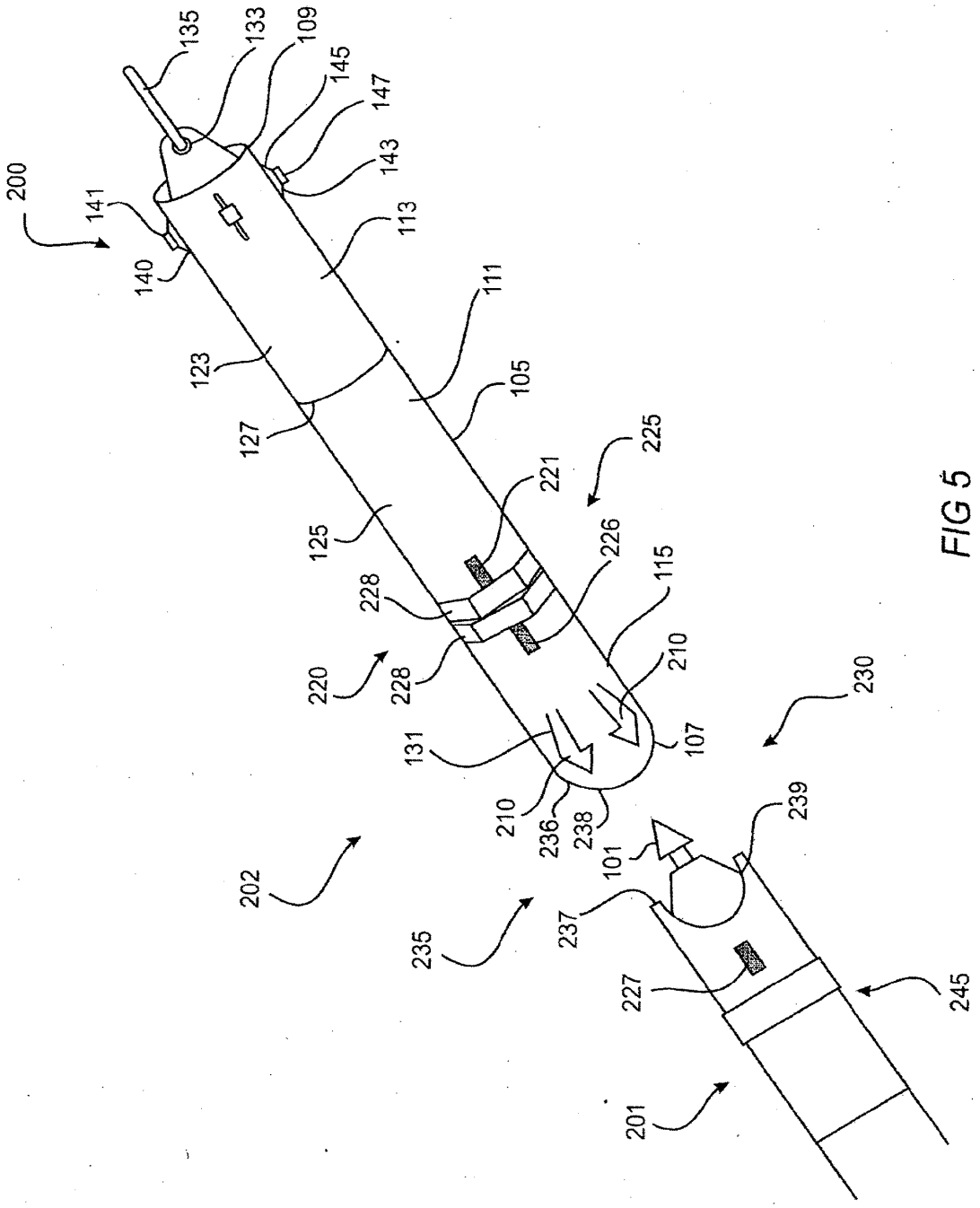


FIG 5

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Reflex USA LLC v. Longyear TM, Inc. and Globaltech Corporation Pty Ltd.

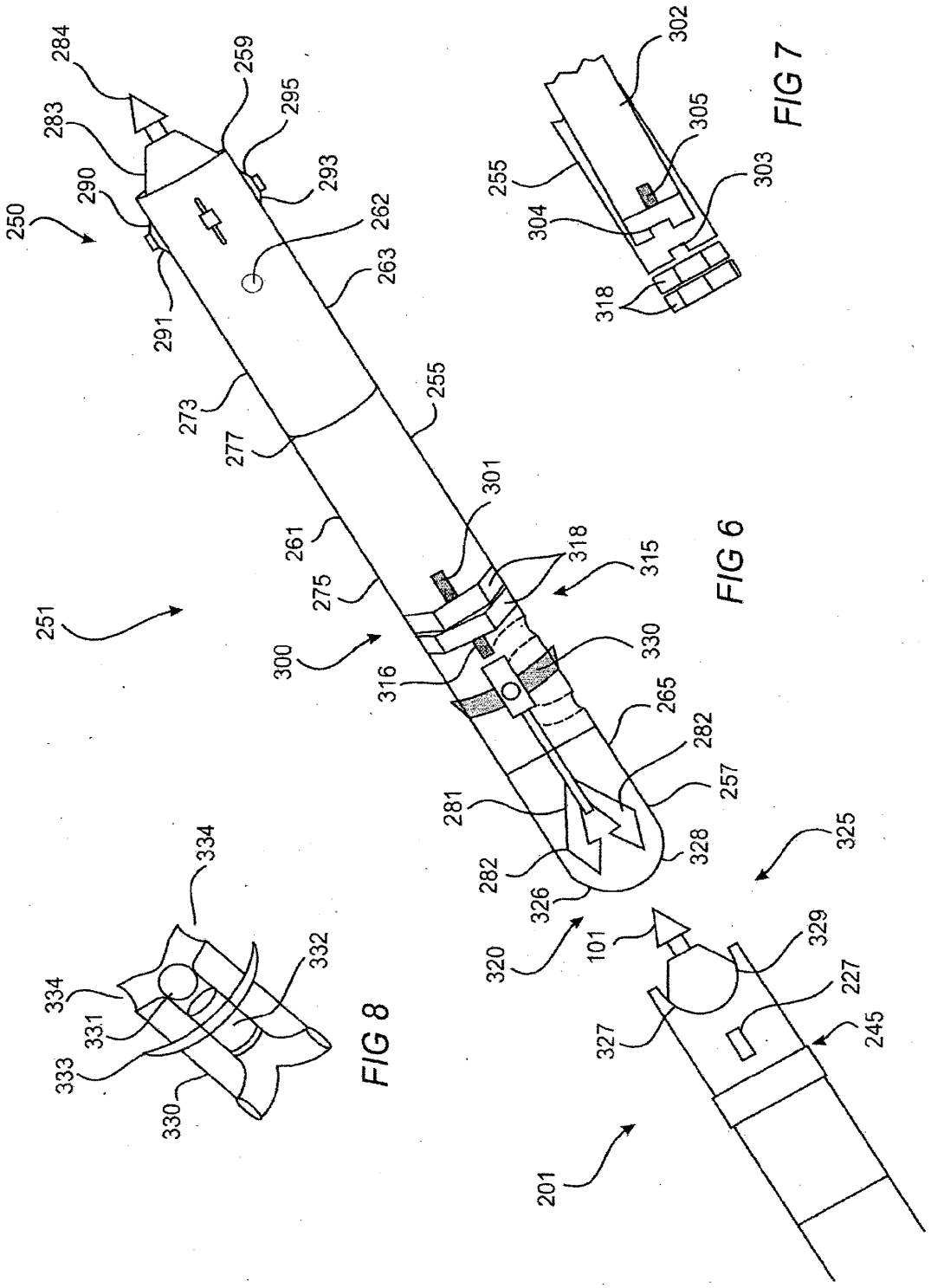


FIG 6

FIG 7

FIG 8

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/AU2012/001132

A. CLASSIFICATION OF SUBJECT MATTER

E21B 25/16 (2006.01) E21B 47/00 (2012.01) E21B 31/18 (2006.01)

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)

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

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

WPI and EPODOC: /EC/IC E21B with keywords: overshot+, survey+, sens+, gyro+, coring, core, sampl+, inner, tube+, drop+, tool+, sub+, centrali+, stabili+, fish+, retriev+, extend+, collaps+, and similar terms

GooglePatents and Espacenet: "overshot survey", "core, sampling survey", "drop tool survey"

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
	Documents are listed in the continuation of Box C	

[X] Further documents are listed in the continuation of Box C [X] 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	Date of mailing of the international search report
9 January 2013	09 January 2013
Name and mailing address of the ISA/AU	**Authorised officer**
AUSTRALIAN PATENT OFFICE PO BOX 200, WODEN ACT 2606, AUSTRALIA Email address: pct@ipaustralia.gov.au Facsimile No.: +61 2 6283 7999	Leopold Filipovic AUSTRALIAN PATENT OFFICE (ISO 9001 Quality Certified Service) Telephone No. 0262832105

Form PCT/ISA/210 (fifth sheet) (July 2009)

INTERNATIONAL SEARCH REPORT C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		International application No. **PCT/AU2012/001132**
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
	US 6006844 A (VAN PUYMBROECK et al) 28 December 1999	
X	Column 6, line 10 - column 13, line 42 and Figures 1-10	1-15, 24-27, 68, 97-104, 114, 115, 117, 119, 121, 122
Y	Column 6, line 10 - column 13, line 42 and Figures 1-10	16-23, 28-36, 37-67, 105, 116, 123 and 124
	US 2004/0251027 A1 (SONNIER et al) 16 December 2004	
Y	Paragraphs 22-46 and Figures 1-9	37-67, 116, 123 and 124
	WO 2006/096935 A1 (RESERVOIR NOMINEES PTY LTD) 21 September 2006	
X	Page 3, line 23 - page 5, line 21 and Figures 1 and 2	69, 70, 80-96, 106-113, 118, 120 and 125
Y	Page 3, line 23 - page 5, line 21 and Figures 1 and 2	71-79
	US 4974691 A (LEANEY et al) 04 December 1990	
Y	Column 6, line 28 - column 7, line 31 and Figures 9-12	16-23, 28-36, 43-51, 71-79 and 105

INTERNATIONAL SEARCH REPORT

International application No.
PCT/AU2012/001132

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a)

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

See Supplemental Box for Details

1. ☒ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:
4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.

☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.

☒ No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT	International application No. PCT/AU2012/001132

Supplemental Box

Continuation of: **Box III**

This International Application does not comply with the requirements of unity of invention because it does not relate to one invention or to a group of inventions so linked as to form a single general inventive concept.

This Authority has found that there are different inventions based on the following features that separate the claims into distinct groups:

- Claims 1-25 are directed to apparatus for us in a downhole survey, claims 26-36 are directed to an inner tube assembly, claim 114 is directed to a method of conducting a borehole surveying operation using a surveying instrument accommodated in an apparatus defined by any one of claims 1 to 25, claim 115 is directed to a method of conducting a borehole surveying operation using a surveying instrument accommodated in an inner tube assembly defined by any one of claims 26 to 36 and claims 121 and 122 are directed to a method of conducting a borehole surveying operation using apparatus (inner tube assembly) incorporating an onboard downhole surveying instrument. The feature of surveying in conjunction with core sampling, wherein a downhole surveying instrument is provided within the body of the apparatus (inner tube assembly) so that the downhole surveying instrument can be conveyed along a borehole is specific to this group of claims.
- Claims 37-67 are directed to an overshot assembly, claim 68 is directed to apparatus for connection to an inner tube assembly, claims 97-105 are directed to a downhole assembly comprising an inner tube assembly in combination with an overshot assembly, claim 116 is directed to a method of conducting a borehole surveying operation using a surveying instrument accommodated in an overshot assembly defined by any one of claims 37 to 67, claim 117 is directed to a method of conducting a borehole surveying operation using a surveying instrument accommodated in an apparatus defined by claim 68, claim 119 is directed to a method of conducting a borehole surveying operation using a surveying instrument accommodated in an inner tube assembly forming part of a combination defined by any one of claims 97-105, claim 123 is directed to a method of conducting a borehole surveying operation using an overshot defined by any one of claims 37 to 67 and claim 124 is directed to a method of conducting a borehole surveying operation using an overshot assembly. The feature of the overshot assembly (apparatus for connection to an inner tube assembly) incorporating an onboard downhole surveying instrument is specific to this group of claims.
- Claims 69-96 are directed to a drop tool assembly, claims 106-113 are directed to a downhole assembly comprising a drop tool assembly defined by any one of claims 69-96, claim 118 is directed to a method of conducting a borehole surveying operation using a surveying instrument accommodated in a drop tool assembly defined by any one of claims 69-96, claim 120 is directed to a method of conducting a borehole surveying operation using a surveying instrument accommodated in a drop tool assembly forming part of a combination defined by any one of claims 106 to 113 and claim 125 is directed to a method of conducting a borehole surveying operation using a drop tool assembly. The feature of the drop tool assembly incorporating an onboard downhole surveying instrument is specific to this group of claims.

PCT Rule 13.2, first sentence, states that unity of invention is only fulfilled when there is a technical relationship among the claimed inventions involving one or more of the same or corresponding special technical features. PCT Rule 13.2, second sentence, defines a special technical feature as a feature which makes a contribution over the prior art.

When there is no special technical feature common to all the claimed inventions there is no unity of invention.

In the above groups of claims, the identified features may have the potential to make a contribution over the prior art but are not common to all the claimed inventions and therefore cannot provide the required technical

Supplemental Box

relationship. The only feature common to all of the claimed inventions and which provides a technical relationship among them is the provision of a downhole surveying instrument onboard a device conveyed along the borehole.

However this feature does not make a contribution over the prior art because it is disclosed in:
D1, D2 and D3

Therefore in the light of this document this common feature cannot be a special technical feature. Therefore there is no special technical feature common to all the claimed inventions and the requirements for unity of invention are consequently not satisfied *a posteriori*.

INTERNATIONAL SEARCH REPORT Information on patent family members	International application No. **PCT/AU2012/001132**

This Annex lists known patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent Document/s Cited in Search Report		Patent Family Member/s	
Publication Number	**Publication Date**	**Publication Number**	**Publication Date**
US 6006844 A	28 Dec 1999	CA 2158903 A1	24 Mar 1996
		DE 19745947 A1	23 Apr 1998
		GB 2293395 A	27 Mar 1996
		GB 2293395 B	08 Oct 1997
		GB 2318372 A	22 Apr 1998
		GB 2318372 B	14 Feb 2001
		NO 953755 A	25 Mar 1996
		NO 311047 B1	01 Oct 2001
		NO 974786 A	11 May 1998
		NO 316886 B1	14 Jun 2004
		US 5568838 A	29 Oct 1996
		US 6006844 A	28 Dec 1999
US 2004/0251027 A1	16 Dec 2004	AU 2004213754 A1	02 Sep 2004
		AU 2004213754 B2	18 Jun 2009
		CA 2516189 A1	02 Sep 2004
		CN 101018926 A	15 Aug 2007
		NO 20054031 A	12 Sep 2005
		RU 2005128349 A	20 Apr 2006
		US 2004251027 A1	16 Dec 2004
		US 7591314 B2	22 Sep 2009
		WO 2004074630 A1	02 Sep 2004
WO 2006/096935 A1	21 Sep 2006	WO 2006096935 A1	21 Sep 2006
US 4974691 A	04 Dec 1990	GB 2220961 A	24 Jan 1990
		GB 2220961 B	25 Nov 1992
		GB 2253427 A	09 Sep 1992
		GB 2253427 B	25 Nov 1992
		GB 2253428 A	09 Sep 1992
		GB 2253428 B	25 Nov 1992
		NL 8901876 A	16 Feb 1990
		NO 892958 A	22 Jan 1990
		US 4974691 A	04 Dec 1990
		US 5048619 A	17 Sep 1991

End of Annex

Due to data integration issues this family listing may not include 10 digit Australian applications filed since May 2001.

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
6 September 2013 (06.09.2013)

WIPO | PCT

(10) International Publication Number
WO 2013/126955 A1

(51) International Patent Classification:
E21B 25/16 (2006.01) *E21B 47/02* (2006.01)

(21) International Application Number:
PCT/AU2013/000179

(22) International Filing Date:
27 February 2013 (27.02.2013)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:

2012900778	28 February 2012 (28.02.2012)	AU
2012903078	20 July 2012 (20.07.2012)	AU
2012903288	1 August 2012 (01.08.2012)	AU

(71) Applicant: **GLOBALTECH CORPORATION PTY LTD** [AU/AU]; 1/48 Vinnicombe Drive, Canning Vale, Western Australia 6155 (AU).

(72) Inventors: **HEJLEH, Khaled**; 34A Leake Street, Peppermint Grove, Western Australia 6011 (AU). **STEWART, Gordon**; 18 Airle Street, Claremont, Western Australia 6010 (AU). **WILKINSON, Brett James**; 17 Quorn Street, Wembley Downs, Western Australia 6019 (AU). **KLASS, Michael Alan**; 37 Raine Terrace, Winthrop, Western Australia 6150 (AU). **ANWAR, Johan**; 20 Prospect Crescent, Kalamunda, Western Australia 6076 (AU).

(74) Agent: **WATERMARK PATENT & TRADE MARKS ATTORNEYS**; GPO Box 5093, Melbourne, Victoria 3001 (AU).

(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, 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, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, 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, LR, LS, MW, MZ, NA, RW, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:

— *with international search report (Art. 21(3))*

(54) Title: IMPROVEMENTS TO DOWNHOLE SURVEYING AND CORE SAMPLE ORIENTATION SYSTEMS, DEVICES AND METHODS

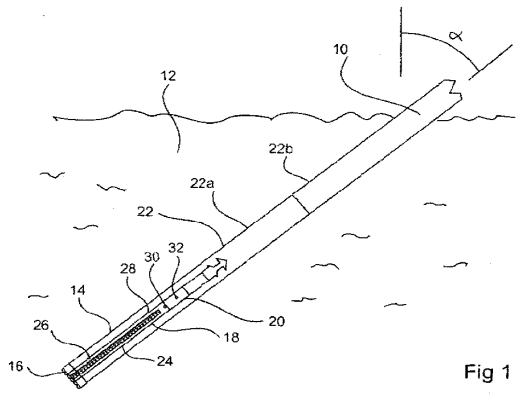


Fig 1

(57) Abstract: A method and system of validating orientation of a core obtained by drilling the core from a subsurface body of material, the method including: a) determining that vibration from drilling is below a nominated level, b) recording data relating to orientation of the core to be retrieved, the data recorded using a downhole core orientation data recording device, c) separating the core from the subsurface body, and d) obtaining from the core orientation data recording device an indication of the orientation of the core based on the recorded data obtained when the vibration from drilling was below the nominated level and before the core was separated from the subsurface body. A method of determining orientation of a core sample obtained by drilling from aboveground into a subsurface body includes recording data relating to a core sample being obtained by the drilling when vibration from drilling is below a threshold; providing an input to a user operated communication device; the communication device identifying a time of the user input to the communication device; retrieving the data gathering device and core sample; communicating between the communication device and the retrieved data gathering device; determining from indications provided by the retrieved data gathering device an orientation of the core sample.

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IMPROVEMENTS TO DOWNHOLE SURVEYING AND CORE SAMPLE ORIENTATION SYSTEMS, DEVICES AND METHODS

FIELD OF THE INVENTION

[0001] The present invention relates to improvements to systems, devices and methods for conducting downhole surveying and determining the orientation of a core sample relative to a body of material from which the core sample has been obtained.

[0002] The present invention further relates to a device, system and method for use in marking orientation of a core sample.

BACKGROUND TO THE INVENTION

[0003] As part of mining/ oil & gas exploration activities, as well as extracting rock samples for construction/ civil engineering, there is a need to obtain underground 'core' samples for analysis by geologists.

[0004] Core orientation is the process of obtaining and marking the orientation of a core sample from a drilling operation. The orientation of the sample is determined with regard to its original position in a body of material, such as rock or ore deposits underground.

[0005] Such core samples are obtained by drilling into an underground medium, such as sedimentary rock, and extracting a solid cylindrical core which reveals, amongst other things, the type of rock, rock strata, presence or absence of minerals or other deposits, and any veins of useful deposits. Core samples can be correlated against each other to reveal trends in rock strata and deposits, which help predict whether mining is worthwhile, and if so, where, in what direction and how deep below the surface.

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[0006] In order to obtain required information from the extracted core samples, a core orientation device is attached between a greaser unit and an inner core tube holding the core sample. The purpose of the core orientation device is to measure and log the orientation of the core with respect to the 'down-side' of the underground location from which it has been extracted. This is an important process as these core samples are used to build a three dimensional profile of existing subsurface resource deposits, such as iron ore or diamonds. If a valuable ore seam is found, it is vital that the core is orientated properly so that a true picture of the ore body can be developed underground.

[0007] Whilst depth and azimuth are used as important indicators of core position, they are generally inadequate on their own to determine the original position and attitude of subsurface geological features. Core orientation enables such details to be determined.

[0008] Orientation of the core sample needs to be obtained from a drilling operation. The orientation of the sample is determined with regard to its original position in a body of material, such as rock or ore deposits underground. Core orientation i.e. which side of the core was facing the bottom (or top) of a borehole and rotational orientation compared to surrounding material, enables such details to be determined.

[0009] Core samples are cylindrical in shape, typically around 3 metres long, and are obtained by drilling with an annular hollow core drill into subsurface material, such as sediment and rock, and recovering the core sample. A diamond tipped drill bit is used at the end of the hollow drill string. As the drill progresses deeper, more sections of hollow steel drill tube are added to extend the drill string. An inner tube assembly captures the core sample. This inner tube assembly remains stationary while the outer tubes rotate with the drill bit. Thus, the core sample is pushed into the inner tube.

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[0010] Once retrieved to the surface, the core end is subsequently marked to indicate orientation of the core sample.

[0011] Current practice involves the core orientation being recorded during drilling, and analysis is undertaken during core logging. The core logging process requires the use of systems to measure the angles of the geological features, such as an integrated core logging system.

[0012] Through core orientation, it is possible to understand the geology of a subsurface region and from that make strategic decisions on future mining or drilling operations, such as economic feasibility, predicted ore body volume, and layout planning. In the construction industry, core orientation can reveal geological features that may affect siting or structural foundations for buildings.

[0013] Typical systems and methodologies presently used periodically record orientation of the core between commencement and end of drilling. Vibration from drilling causes many recorded orientation results to be inaccurrate or not needed because orientation before end of drilling is not required or used. This needless recordal of data wastes the limited power of the onboard battery powering the orientation sensors, and thereby limits the amount of time an orientation unit can remain downhole before needing a recharge or battery replacement.

[0014] Apart from analyzing this content of the core sample, it is also necessary to determine the 'orientation' of the core(s) with respect to the drilling angle and depth from the earth's surface and the direction of rotation of the core, at the source of extraction. These measurements are used as an aid in determining the consistency and direction of deposits, such as ore content, and for producing a 3D 'picture' of underground mineralization.

[0015] After retrieving the core sample to the surface, the core orientation device will then be used to electronically or mechanically determine the core's

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orientation before being drilled out. The operator would have to rotate the whole inner tube so as to position the core tube such that the core is set in an up/down position in the core tube. This gives a correct reference for the original orientation of the material in the core when it was attached to the ground material prior to extraction. The core sample end is then visually marked to show the correct up/down orientation for later analysis.

[0016] It has been realised that the methodology of obtaining the desired orientation of the core representative of the point at which the core was 'broken' away from the body from which it is drilled could be improved.

[0017] To this end, it has been found desirable of the present invention to provide a method and system of obtaining an indication of core orientation that reduces power demand on the orientation unit and avoids the need to record orientation data that is not needed. This aims to simplify and speed up the core orientation data gathering process.

[0018] Core orientation is recorded during drilling, and analysis is undertaken during core logging. The core logging process requires the use of systems to measure the angles of the geological features, such as an integrated core logging system.

[0019] Through core orientation, it is possible to understand the geology of a subsurface region and from that make strategic decisions on future mining or drilling operations, such as economic feasibility, predicted ore body volume, and layout planning. In the construction industry, core orientation can reveal geological features that may affect siting or structural foundations for buildings

[0020] In a drill string, a 'back end' assembly connects to a greaser. This greaser lubricates the back end assembly which rotates with the outer casing while the greaser remains stationary with the inner tubing.

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[0021] Once a core sample is cut, the inner tube assembly is recovered by winching to the surface. After removal of the back end assembly from the inner tube assembly, the core sample is recovered and catalogued for analysis.

[0022] Various core orientation systems have previously been used or proposed. Traditional systems use a spear and clay impression arrangement where a spear is thrown down the drill string and makes an impression in clay material at an upper end of the core sample. This impression can be used to vindicate the orientation of the core at the time and position the spear impacted the clay.

[0023] A more recent system of determining core oprientation is proposed in Australian patent number 2006100113 (also as US patent number 7,584,055). This patent document describes a core orientation device for a core drill. The device provides signals associated with a physical orientation of a core orientation device for a particular moment in time. The device includes a memory for storing and providing the orientation data when required. The system described in AU 2006100113 provides a two unit replacement for the greaser described above. A first orientation system unit houses electronics and a battery used to record orientation data, and the second greaser unit is an extended greaser accommodating a physical screw on connector for the first unit as well as serving as the greaser. This combination forms part of the inner tube assembly with the core tube, orientation system 'first' unit and the connector/greaser 'second' unit. However, as a result of the now extended length of the combined orientation system and greaser units compared with a standard greaser only unit, the outer drill string casing now requires a matching extension piece to extend the outer casing an equal amount. The core orientation system has a display on one face which is used when setting up the unit prior to deployment, and to indicate core sample alignment when the core sample is recovered. At the surface before removing the core sample from the inner tube assembly, the operator views the display fitted on the system. The display indicates for the operator to rotate the unit and the sample within the tube until the whole core tube and sample is

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oriented with the lower section of the core sample at the lower end of the tube. The core sample is marked (usually by pencil) before being removed from the core for future analysis.

[0024] However, the device described in AU 2006100113 has been found to have certain limitations. The orientation unit is connected to the greaser by a screw thread and o-ring seal arrangement. In the harsh down hole environment within the drill string, it has been realised that the o-ring seals are not always effective and can let fluid into the space between the orientation unit and the greaser. The display unit allows fluid into the electronics of the orientation, resulting in a risk of fault or failure of the device. Furthermore, the orientation unit must be disassembled from the greaser unit before the display and orientation unit can be viewed, rotated and the required core orientation displayed. Thus, the device of AU 2006100113 requires manual manipulation before any reading can be viewed on the display, if the display and the electronics have survived any ingress of fluid past the o-ring seal.

[0025] Furthermore, a problem has been identified in the known art. Battery powered downhole survey equipment, such as probes and core orientation units, are typically switched on at the surface and run almost continuously or operate on a frequent timer basis. For example, a known core orientation device the subject of Australian patent application AU 2010200162 takes measurements determined by a timer whether or not the values obtained are worthwhile or accurate. This leads a large amount of unusable data which is typically discarded and such continuous or too often recording of data unnecessarily rapidly reduces battery life of the downhole device. Such known arrangements may only last a few weeks or months before the downhole device needs recharging or replacing. Often spare equipment is held on hand just in case the batter fails. This leads to far too much equipment being needed, at an increased cost to the drilling operator. It would be beneficial to reduce reliance on holding spare equipment on hand.

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[0026] In addition, it has been realised that, during the drilling process, if sections of fragmented earth are drilled into (resulting in fractured core samples) then the inner tube can rotate. Furthermore, vibrations caused by drilling have also been identified as a cause of inaccurate data.

[0027] Also, it has been realised that only a limited amount of downhole data is actually required in order to later determine correct orientation of a core sample at the surface. It has been realised that data recording on a continuous or frequent periodic basis whilst drilling is occurring is unnecessary. Only down orientation of the core sample needs to be known, and provided data relating to the down orientation can be identified and referenced to a particular known time, core orientation can be determined.

[0028] It has therefore been found desirable to provide improved downhole data recording through a system, device and method that alleviates one or more of the aforementioned problems whilst facilitating more reliable data recovery.

[0029] After retrieving the core sample to the surface, the core orientation device will then be used to electronically or mechanically determine the core's orientation before being drilled out. The operator would have to rotate the whole inner tube so as to position the core tube such that the core is set in an up/down position in the core tube. This gives a correct reference for the original orientation of the material in the core when it was attached to the ground material prior to extraction.

[0030] Personnel then physically 'mark' the lower end position of that core sample end face protruding from the core tube with a wax pencil or similar marker (usually a red wax pencil). In order to accurately mark the 'lower end' of the core face, a device is used to determine the position to mark the core. This is usually achieved with the aid of spirit-level v-block devices to determine the position to place the 'lower-end' mark on the core face.

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[0031] This procedure, although straightforward, is often carried out incorrectly, leading to incorrect marking of the orientation of the core. This error is often due to insufficient training, lack of understanding due to language barriers, operator fatigue, ineffectually carrying out of the procedure or basic v-groove spirit level devices not being used correctly or their correct use not being easily understood.

[0032] Incorrect marking of the core orientation through human error leads to poor geophysical analysis and results. It has been found that geologists, on realising the marking error, have needed to search through core samples and determine the correct orientation. This loses many man hours of work in having to go back through the original core samples and identify the correct orientation, and until this is done, further development of the worksite cannot be accurately carried out. Mining may commence or continue in the wrong place and/or may miss the vein of resource.

[0033] With the aforementioned in mind, it is desirable of the present invention to provide improved means and way by which core sample orientation can be accurately marked.

SUMMARY OF THE INVENTION

[0034] With the aforementioned in mind, in one aspect the present invention provides a method of validating orientation of a core obtained by drilling the core from a subsurface body of material, the method including: a) determining that vibration from drilling is below a nominated level, b) recording data relating to orientation of the core to be retrieved, the data recorded using a downhole core orientation data recording device, c) separating the core from the subsurface body, and d) obtaining from the core orientation data recording device an indication of the orientation of the core based on the recorded data obtained when the vibration from drilling was below the nominated level and before the core was separated from the subsurface body.

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[0035] Preferably the core orientation data recording device activates from a standby mode after detecting that vibration from drilling is at or below the nominated level. The nominated level may coincide with no drilling occurring - to indicate that the core has been received in the inner core tube by drilling. The core orientation data recording device may then determine an indication of core orientation. The core may then be separated from the body of material.

[0036] An alternative form of the present invention provides a method of recording core orientation data from a drilling operation when obtaining a core from a subsurface body of material, the method including: determining that drilling has ceased for a period of time, using a downhole core orientation data recording device to record data relating to orientation of the core to be retrieved, separating the core from the subsurface body, retrieving the core to the surface, and obtaining from the core orientation data recording device an indication of the orientation of the core based on the recorded data obtained once the drilling had ceased and before the core was separated from the subsurface body.

[0037] When drilling has ceased is preferably the end of drilling immediately prior to obtaining the core. That is, recording the data relating to orientation of the core is obtained preferably after final drilling has been completed prior to obtaining the next core sample.

[0038] Preferably no further data relating to core orientation is obtained after separating the core from the subsurface body. This confirms that no further data is required in order to identify (and subsequently mark) the required correct orientation of the core for later analysis of the core.

[0039] Once drilling has ceased, a predetermined time interval may elapse before the core is separated from the subsurface body.

[0040] Alternatively, or in addition, a predetermined time may elapse after drilling has ceased until the core orientation data is obtained and then the core is

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subsequently separated from the subsurface body of material. Consequently, the core may be separated from the subsurface body at any instance after the data is recorded provided the drilling does not recommence before the core is separated. If drilling recommences, the drilling must cease for a period of time and fresh orientation data is obtained before the core is separated.

[0041] For clarity, the core orientation device does not orientate the core, rather, it records signals indicative of the orientation of the core to be retrieved. Core orientation device and core orientation data recording device are the same in this description.

[0042] Preferably any core orientation data samples obtained during drilling or at intervals between periods of drilling are not used, or are disregarded, when determining orientation of the core.

[0043] When the drilling ends and the operator is ready to separate the core, preferably a predetermined period of time when there is no drilling is allowed to elapse before the core is separated. The predetermined period may be 10 seconds or more of no drill rotation. Preferably that period does not exceed 90 seconds.

[0044] In addition to core orientation, dip measurement may be obtained during the period of drilling 'silence' i.e. when drilling has ceased prior to separating the core.

[0045] The core may be separated from the subsurface body by breaking, such as by a strong sharp pull back of the inner tube of the drilling assembly. The operation of breaking the core should take less than 1 minute, preferably less than 30 seconds and more preferably between 10 seconds and 30 seconds.

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[0046] After separating the core from the subsurface body, a period of time elapses without any further drilling or rotation, or retrieval of the drilling assembly occurring. This period is preferably greater than 90 seconds.

[0047] The core orientation device may be sensing for presence or absence of vibration from drilling (or both sensing and recording), and preferably determining whether core orientation data is obtained during a first period when there is no drilling, and preferably determining when the core sample is separated (by detecting related vibration(s)), and preferably determining that the second period of no drilling has occurred after the core separation. The purpose of these timings is to identify the correct 'signature' of 1) no drilling vibration, 2) separation (breaking) of the core, and 3) no drilling. Preferably, if one of these criteria is not met then the data sample or the core sample obtained will be disregarded.

[0048] Separation of the core from the subsurface body of material may be determined by detecting acceleration, change of acceleration, or detecting tension or strain, or change in tension or strain, or combinations thereof, resulting from a force applied to the core and the core separating from the subsurface body.

[0049] Alternatively, the period of time immediately preceding separation may be determined by a change in the total pressure surrounding the core orientation device or a change in differential pressure between the outside and inside of the core tube, or a predetermined pressure level being reached or exceeded either as a differential pressure or total pressure.

[0050] The force may be applied by pulling backwards (in the Z direction back up the borehole) the inner tube holding the core. This can be achieved by an overlock assembly being attached to the backend assembly associated with the inner tube and core.

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[0051] The Z direction is taken to be the direction of the borehole or drill hole. X and Y directions define planes or directions orthogonal to the Z direction i.e. at right angles to the linear direction of the borehole.

[0052] Acceleration or change of acceleration (jerk) may be termed negative acceleration because the force applied tries to pull the core in the direction back up the borehole.

[0053] Acceleration or change in acceleration is detected by at least one accelerometer provided within the core orientation data recording device. A three axis accelerometer (X,Y,Z directions) may be used. As mentioned above, acceleration or change in acceleration detected may be in a Z direction in line with an advancing drilling activity i.e. the linear direction of the borehole.

[0054] Tension or strain or change in tension or strain may be detected by at least one strain gauge within or on a portion of the downhole equipment associated with obtaining the core. At least one strain gauge may be provided within or on the core orientation data recording device or within or on a section of drill tube. The at least one strain gauge may be electrically connected to the core orientation data recording device.

[0055] Change in total pressure within, or presence or change of a pressure differential between the interior and exterior of, the inner core tube can be detected by at least one pressure sensor. The at least one sensor may be provided within or on, or both, the core orientation data recording device and/or within a section of the inner tube assembly. Pressure above a threshold may be detected.

[0056] At least one of the at least one pressure sensor may be electrically or optically connected to the core orientation data-recording device.

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[0057] The change or presence of the pressure may be used to determine a point at which the core should be separated from the subsurface body of material. For example, a pressure measurement or change in pressure may be used to determine that the inner core tube is full or nearly full of core and it is time to retrieve the core. In which case, drilling can cease, the core orientation data recording device can take measurements (such as of core orientation position, gravitational field direction and strength, magnetic field direction and strength etc.) and the core can then be separated from the subsurface body.

[0058] One or more forms of the present invention may be provided by a system including at least a core orientation data recording device and a core drilling assembly. Preferably the system includes a remote communication device configured to communicate with the core orientation data recording device to identify a required orientation of the core.

[0059] The core orientation data recording device may include at least one visual indicator to show one or more of a direction to rotate the core to obtain the required orientation or a visual indication to show the required orientation.

[0060] With the aforementioned in view, at least one form of the present invention provides a method of determining orientation of a core sample obtained by drilling from aboveground into a subsurface body, the method including:

a) operating a downhole data gathering device to detect when vibration from drilling is below a threshold;

b) recording data relating to a core sample being obtained by the drilling when vibration from drilling is below the threshold;

c) providing an input to a user operated communication device;

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d) the communication device identifying time of the user input to the communication device;

e) retrieving the data gathering device and core sample;

f) communicating between the communication device and the retrieved data gathering device;

g) determining from indications provided by the retrieved data gathering device an orientation of the core sample.

[0061] Obtaining data when vibration from drilling is below a threshold, preferably when there is no drilling and therefore no vibration from drilling at all, enhances reliability and accuracy of the data. For example, magnetic, gravity and inclination values have been found to be more accurately when no drilling is occurring. Drilling activity can cause inaccuracies in the data. This results in multiple data sets saved in known devices simply being unusable. Processing unusable data within the survey probe or externally (such as by experts assessing the data) is uneconomical and a waste of time, money and resources. Also, and of great benefit, the data gathering device can 'go to sleep' in a standby mode while drilling is occurring and no data is being collected. This greatly enhances battery life in the data gathering device. By only waking to take sampling shots when no vibration is detected, the present invention greatly increase battery life.

[0062] The communication device may use an internal clock or timer to 'mark' or identify a user input. For example, the user input may commence a timing period of an internal clock or timer.

[0063] The input to the communication device, such as a user operating one or more buttons or touch screen controls, on the communication device may include one or more of; an indication of a most recent occurrence when drilling

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ceased; an indication immediately prior to separating the core sample from the subsurface body and/or an indication after separating the core sample from the subsurface body.

[0064] The communication device may be used to activate/deactivate the data gathering device, such as to cease gathering data.

[0065] The data gathering device may be used to provide survey data to the communication device or another receiver, the survey data being or derived from recorded data obtained when the no vibration had been detected.

[0066] The data gathering device may be operated to provide to the communication device survey data relating to recorded data obtained prior to a defined period of time.

[0067] The defined period of time may be provided to the retrieved data gathering device from the communication device.

[0068] The defined period of time may be used by the data gathering device to identify recorded data obtained during surveying at a time prior to the amount of the defined time.

[0069] Identified recorded data provided as survey data to the communication device or other receiver may be from recorded data recorded by the data gathering device at a period in time closest to the time prior to the amount of defined time than any other recorded data event.

[0070] The data gathering device may be operated to detect that vibration is occurring and to therefore wait until a subsequent no vibration event occurs before recording data.

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[0071] The data gathering device may be employed to detect multiple consecutive survey values during a period of no vibration.

[0072] Acceptable recorded data may be identified with a timestamp relating to real time.

[0073] A further aspect of the present invention provides a system for use in determining orientation of a core sample obtained by drilling from aboveground into a subsurface body, the system including a data gathering device arranged and configured with control means to detect when vibration from drilling is below a threshold, and activation means to cause the data gathering device to record data during the period of vibration below the threshold.

[0074] Downhole survey equipment that 'goes to sleep' when it would otherwise record data that is unnecessary to collect or not worthwhile collecting because of inaccuracies greatly saves on battery power and therefore lengthens the life of the downhole device before the battery needs replacing or recharging. This means that high value (cost and functional value) equipment can remain in use in the field when known equipment would otherwise need replacing. This can avoid the need to hold multiple pieces of battery powered survey equipment on hand just in case one loses power.

[0075] Preferably the threshold it set at no vibration from drilling.

[0076] Vibration from drilling results from the drill bit cutting into the sub-surface body to advance the drill string and from rotation of the drillstring tube.

[0077] The data gathering device including a timer providing a timestamp for recorded data events.

[0078] Preferably, when drilling stops and vibration is detected to be below the threshold, the data gathering device activates (wakes from standby) and

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records core orientation data (takes a core orientation 'shot'). The core is then broken from its connection with the ground (no further drilling being required). The core sample can be separated from the ground to which it is connected by yanking or jerking axially along the axis of the drill string.

[0079] One or more forms or embodiments of the present invention provides or includes a method whereby, when drilling is stopped;

a) the data gathering device records core orientation data;

b) the core is subsequently separated from its connection with the ground;

c) the communication device signals to the data gathering device to identify the recorded core orientation data that was immediately prior to separating the core sample from the ground; and

d) using that recorded core orientation data to identify orientation of the core sample.

[0080] A communication device as part of the system includes communication means arranged and configured to communicate a time value to the data gathering device, the data gathering device including processing means which determines from the received time value the closest recorded data obtained immediately prior to a time determined by subtracting the received time value from a current time value.

[0081] The current time value (preferably a real time value or a time quantity) may be provided by the communication device to the data gathering device.

[0082] An alternative aspect of the present invention provides a method of obtaining downhole survey data in a borehole created by drilling, the method

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including advancing a data gathering device into the borehole, the data gathering device determining that vibration is below a predetermined threshold, bringing the data gathering device out of a standby mode during a period when vibration is determined to be below the threshold, recording data during the period, returning the data gathering device to a standby mode when vibration is determined to be above the threshold or sufficient said data has recorded.

[0083] Thus, a preferred concept of reducing power consumption in downhole survey tools is realised. A standby, or low power mode, reduces power consumption to a minimum while vibration is detected to be above a threshold limit.

[0084] An alternative aspect of the present invention provides a method of determining selection of downhole survey or core orientation data of a respective downhole survey or core orientation device, the method including;

a) providing a data recorder, the recorder arranged to record data relating to downhole surveying or core sample orientation;

b) providing a communication device remote from the data recorder, the communication device having a timer and remaining at a ground surface when the data recorder is below ground;

c) commencing timing with the timer;

d) operating the data recorder to record one or more data events whilst downhole;

e) subsequent to communication device commencing the timing, signalling to the data recorder to provide or identify a recorded data event, the recorded data event being determined by the communication device to be a predetermined period of time prior to the signalling to the data recorder.

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[0085] Thus, the communication device, which may also be termed a communication device, and the data recorder, which may also be termed a data gathering device, are not time synchronised to each other, and yet the data recorder can be interrogated to provide a required data set or record from a set period time prior to being signalled. For example, the communication device, with its own timer running, may be used to 'mark' a specific moment. At this stage, the data recorder has its own timer running, unsynchronised to the timer of the data recorder. A period of time after the 'mark' recorded, the communication device signals to the data recorder to identify or note a data set or record previously recorded a set period of time ago. The data recorder then checks its memory for the recorded data set or record closest to the end of the set period of time that the communication device has signalled to the data recorder to look back.

[0086] A further aspect the present invention provides a core sample orientation system configured to provide an indication of the orientation of a core sample relative to a body of material from which the core has been recovered, the system including a hermetically sealed core sample orientation data gathering device deployable as part of a downhole core sample assembly.

[0087] Communication means may be arranged to communicate obtained core sample orientation data to a remote orientation data indication display device having an orientation data display.

[0088] A further aspect of the present invention provides a hermetically sealed core sample orientation data gathering device when deployed as part of a core sample orientation system for providing an indication of the orientation of a core sample relative to a body of material from which the core has been extracted.

[0089] The orientation data gathering device may include communication means for providing core sample orientation data to a remote orientation data electronic device having an orientation data display.

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[0090] Thus, the orientation data gathering device of the present system being hermetically sealed avoids risk of ingress of liquid when the downhole, thereby leading to more reliable data gathering operations without the need to recover the device prematurely in order to repair or replace a faulty device, or risk completing a core sampling operation but find at the surface that no data can be recovered and the core orientation cannot be accurately determined.

[0091] The orientation data gathering device may be connected to a standard greaser unit, thereby allowing known equipment to be used and avoiding the need for specialised greaser to be adopted. Because the orientation data gathering device is hermetically sealed to ensure no liquid gets in to the device when deployed downhole, and the device has communication means to send data signals to a remote display, no o-ring seal to the greaser is required. This saves on unreliable o-ring seals, reduces risk of damage through water ingress and loss of data, as well as the time saved in not having to recover the damaged device and redeploy a replacement.

[0092] The system may further include timer means to commence multiple time intervals for the device to obtain orientation data. A time interval may be synchronised at an orientation reading time and the time interval related to a predetermined time interval. This may be achieved by use of the remote orientation data electronic communication device. System start up, setup, stop and data recovery functions may be carried out using the remote orientation data electronic communication device to operate the orientation data gathering device.

[0093] The orientation data gathering device may have one or more visual indicators to show an operator one or more required directions of rotation of a recovered core sample assembly for determining orientation of the core sample, and once a required core sample orientation has been established, the remote orientation data electronic communication device may interrogate the orientation data gathering device to obtain orientation data.

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[0094] Communication between the orientation data gathering device and the remote orientation data electronic communication device is by wireless communication, such as infra red communication.

[0095] The remote orientation data electronic communication device may include a display to show visual information relating to the obtained orientation data, such as an indication that sufficient data has been obtained, that the data is correctly and safely stored and/or that data has been transferred from the orientation data gathering device to the remote orientation data electronic communication device.

[0096] The orientation data gathering device may include one or more visual and/or audible indicators relating to a direction of rotation of the device when determining core sample orientation and/or when a required core sample orientation has been determined. For example, illuminated indicators may be provided on the device, such as on an end of the exposed when the greaser is removed. However, the greaser does not have to be removed, as the light can actually be seen through the existing holes in an off the shelf greaser. A particular colour, number of lights or direction indication may illuminate to indicate that the device and the core sample need rotating in one direction, and a different colour, number of lights or direction indication may illuminate to show an opposite rotation direction is needed. These may be augmented by or replaced by audible indications, such as respective numbers of 'bleeps'. An illuminated and/or audible indication may be given when a required core sample orientation is achieved. For example, both direction lights or audible signals may be given at the same time.

[0097] The remote orientation data communication device may also give an indication of the required direction of rotation and/or required core sample orientation.

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[0098] The remote orientation data communication device may include or be a handheld unit. This unit may include a battery for power, which may be a rechargeable battery.

[0099] A further aspect of the present invention provides a method of obtaining core sample orientation data, the method including:

a) deploying a core sample orientation data gathering device as part of a core sample gathering system;

b) obtaining a core sample from a subsurface body of material using the apparatus;

c) using the orientation data gathering device to determine the orientation of the core sample relative to the subsurface body of material; and

d) using a remote communication device to obtain from said orientation data gathering device data relating to the orientation of the core sample.

[00100] The method may further include hermetically sealing the core sample orientation data gathering device prior to deployment.

[00101] Following recovery of the device, core orientation indications may be given by one or more illuminated and/or audible indications. Coloured indications may be used to determine a required orientation of the core sample. For example, the orientation data gathering device may include lights, such as LEDs, whereby an indication is given to rotate the core sample in a first direction or in a second opposite direction to obtain a required core sample orientation position, or lights may be used to indicate when a required orientation position has been obtained.

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[00102] The method may include deploying the orientation data gathering device leading a greaser. The greaser device may preferably be a standard greaser.

[00103] Multiple time intervals may be measured by the device. These time intervals can be used to determine data gathering events, such as position, magnetic flux, gravity, velocity, acceleration etc. A time interval can be synchronised to a specific downhole data gathering event.

[00104] Data may be obtained from the orientation data gathering device by communication with a remote device, such as by an infra red link or other wireless communication, such as radio link, between the orientation data gathering device and an orientation data communication device.

[00105] A data gathering device according to one or more forms of the present invention does not continuously take 'core orientation' readings while in use. Instead, such a device determines when the device is 'motionless' (through its in-built firmware algorithms and sensors) before taking orientation readings. This arrangement of orientation recording confirms that the device only records valid data, i.e. while motionless, as the in-built sensors would otherwise present faulty or indeterminate readings.

[00106] If an operator erroneously selects a time interval for 'core orientation' (via the handheld unit while the data gathering device is still in motion), after retrieving the core sample, algorithms programmed into the device will determine the 'best-approximate' time interval relative to the device being 'steady' or 'motionless' at a time before or after a time selection by the operator using a hand held unit to communicate with the device as part of an embodiment of the system. The event and time difference will also be reported to the operator to confirm acceptance of that recorded data.

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[00107] After core retrieval, the data gathering device provides an indication, using one or more light emitting diodes (LEDs), used to determine correct orientation of the core sample after rotating the device and core tube assembly in either direction (no indication of left or right direction is required). The LEDs do not necessarily indicate direction, but provides 'multi-level-speed' LED flashing rates, followed by a steady ON state LED illumination to determine correct core orientation. One or more other systems using various colours and flash rates, etc could be employed.

[00108] According to one or more embodiments of the present invention, before inserting the down-hole data gathering device into a drill hole, and after retrieving the same unit with the obtained core sample, the wireless handheld unit can start/stop or interrogate the down-hole device without having to remove or unscrew the unit from the drill-string or core tube sections. The handheld unit does not need to be attached, screwed in, mounted to or wedged to any part of the tubing or GCOU assembly during any operation).

[00109] Start/stop operations, setting the exact time for orientation, interrogating and recording 'confirmed-accurate' operator orientation procedure, may all be performed using a remote wireless hand-held unit communicating with the data gathering device unit that was down the drill hole.

[00110] Visual indication of core sample orientation may be provided through at least one aperture in a sidewall of a section of a downhole assembly. Core sample orientation indications may be as light through at least one aperture in the sidewall of a section of the downhole assembly, such as a greaser unit. Core sample orientation visual indications may be provided from one or more light emitters via at least one light reflector, and preferably reflecting that emitted light out through the at least one aperture.

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[00111] Whenever a core sample is drilled out from underground and placed on the surface, the core sample must be re-orientated to its original position that it was found.

[00112] One or more forms of the present invention aims to remove or reduce the human error aspect of this process present in known systems.

[00113] One or more forms of the present invention may include marking the core automatically and correctly, thus ensuring correct orientations of core samples and valid data is received by geologists.

[00114] According to one aspect the present invention provides a core orientation marking system to provide an identification mark on a core indicating a desired orientation of the core extracted from a below ground body of material, the system including a core orientation identification device and a marker device, the core orientation identification device including an alignment means and a mounting means to mount the device relative to an end of a tube exposing an end of the core to be marked, the mounting means permitting the device to rotate about the end of the tube, the alignment means arranged to provide an indication of correct alignment of the device relative to a known alignment of the core, and the marker device providing an identifiable mark on the end of the core corresponding to the known alignment of the core.

[00115] The core orientation identification device may be manually rotated about the tube end or rotated by force of gravity.

[00116] The core orientation may be marked on an end of the core manually or automatically.

[00117] The core orientation identification device may include at least one light arranged to indicate when the device is correctly orientated relative to the core to identify the required core orientation. The at least one light may be controlled to

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flash to indicate orientation is not yet correct. The at least one light may be controlled to flash slower the nearer to correct orientation is achieved by rotating the device about the tube and shows steady when correct orientation is identified.

[00118] Preferably, correct orientation is upright or substantially vertical relative to a corresponding upright or substantially vertical alignment of the orientation of the core.

[00119] The device may include two or more biased opposed members permitting width adjustment for mounting the device to respective tubes of a variety of diameters. The biased opposed members may include at least two opposed jaws. The biased opposed members may include rollers that are brought into contact with the tube when the device adjusts to the diameter of the tube and wherein the device is arranged to rotate by force of gravity about the tube.

[00120] The marker device may be incorporated as part of the core orientation identification device.

[00121] A system according to one or more forms of the present invention may include electronics and a power source for the electronics, the electronics including one or more accelerometers to detect correct orientation of the device and to send a signal or cease send a signal to indicate the correct orientation of the device relative to the known orientation of the core.

[00122] The marker device may be actuated automatically to mark the core by remote operation from a remote controller.

[00123] Position of the marker relative to the core end may be adjustable by an adjustment means. Position adjustment may be height, distance towards/away from or both, relative to the core end. The adjustment means may be mounted to the device.

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[00124] The core orientation identification device may include a latch mechanism that is released upon receipt of a release signal to effect marking the core. The latch mechanism including a solenoid operated release.

[00125] The system may include a remote controller arranged to send a signal to the device to effect core marking, and the device includes electronics to detect whether the device is correctly orientated relative to the core, and to effect marking if orientation of the core and device correspond, and to prevent marking if the orientation of the core and device do not correspond.

[00126] Successful marking is logged in a memory of the remote controller or transmitted to another device.

[00127] Another aspect of the present invention provides a method of marking core orientation on a core sample, the method including using a device to automatically identify a correct orientation of the core, and marking that correct orientation on the core with a marker.

[00128] The method may include electronically actuating the marker to mark the core when the correct orientation is identified.

[00129] The method may include releasing a latch mechanism to release the marker to automatically mark the core. The latch mechanism may be released by receipt of a signal from a remote controller.

[00130] Correct orientation of the device relative to the core may be achieved by rotating the device under the force of gravity about a tube containing the core.

[00131] Successful correct marking of the core may be logged in an electronic device. The electronic device may include the core orientation identifying device and/or the remote controller.

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BRIEF DESCRIPTION OF THE DRAWINGS

[00132] Figure 1 shows a general arrangement of a drill assembly for obtaining core sample according to an embodiment of the present invention.

[00133] Figure 2 shows an example of a flowchart relating to a method according to an embodiment of the present invention.

[00134] Figures 3 and 4 show features of a known core sample orientation system.

[00135] Figures 5A, 5B and 6 show features of an arrangement of a core sample orientation system according to an embodiment of the present invention.

[00136] Figure 7 shows a core sample orientation data gathering device according to an embodiment of the present invention.

[00137] Figure 8 shows a hand held device for interrogating the core sample orientation data gathering device according to an embodiment of the present invention.

[00138] Figure 9 shows an indicator window end of a core sample orientation device according to an embodiment of the present invention wherethrough indicator lights can show when illuminated.

[00139] Figures 10a and 10b show an alternative embodiment of a data gathering device of the present invention.

[00140] Figure 11 is a flow chart showing steps involved in obtaining usable recorded data of downhole survey equipment for determining orientation of a core sample according to an embodiment of the present invention.

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[00141] Figure 12 is a flow chart of selection of useable data for use in determining core sample orientation according to an embodiment of the present invention.

[00142] Figures 13 to 15 show the device in place ready for marking the lower face of the core after orientation, and which is still within the core tube;

[00143] Figure 16 shows a view of the device with wheels used to locate and orientate the device via gravity before marking the core end face.

[00144] Figure 17 shows a sectional view of a portion of the device with a marker within a spring loaded cartridge.

[00145] Figure 18 shows a system according to an embodiment of the present invention including a remote device communicating with the device of figures 1 to 5 and used to confirm correct lower side core orientation.

[00146] Figure 19 shows a sectional view through a core marking device according to an embodiment of the present invention.

[00147] Figures 20a to 20c show respective side, perspective and end views of an alternative embodiment of a core marking device of the present invention.

[00148] Figures 21a to 21c show respective top, perspective and side section views of part of the alternative embodiment of a core marking device of the present invention shown in figures 20-20c.

[00149] Figures 22a to 22e are sectional views showing steps in the operation of an embodiment of the core marking device.

DESCRIPTION OF PREFERRED EMBODIMENT

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[00150] The present invention includes an embodiment with detection of a core for retrieval by separation or 'breaking' from the body of material from which it is drilled.

[00151] A drill assembly 10 for drilling into a subsurface body of material 12 includes a drillstring 14 including a drill bit 16 an out tube 22 formed of linearly connected tube sections 22a,22b..., and an inner tube assembly 18 including an inner tube 24 for receiving the core 26 drilled from the subsurface body.

[00152] One or more pressure sensors 28,30,32 can be provided to detect pressure, change in pressure and/or pressure differential. These can communicate with the core orientation data recording device and/or an operator at the surface. Once a required pressure value is detected, drilling can cease and the core orientation device can record data relating to the orientation of the core, such as gravitational field strength and direction, and/or magnetic field strength and direction.

[00153] Digital and/or electro-mechanical sensors, and/or one or more pressure sensors in a core orientation data recording device 20 are used to determine the core orientation just prior to the core break, and to detect the signal of the break of the core from the body of material.

[00154] Data recorded or used may optionally include 'dip' angle α to increase reliability of core orientation results.

[00155] Dip (also referred to as inclination or declination) is the angle of the inner core tube drill assembly with respect to the horizontal plane and can be the angle above or below the horizontal plane depending on drilling direction from above ground level or from underground drilling in any direction. This provides further confirmation that the progressive drilling of a hole follows a maximum progressive dip angle which may incrementally change as drilling progresses, but not to the extent which exceeds the 'dogleg severity'. The 'dogleg severity' is a

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normalized estimate (e.g. degrees / 30 metre) of the overall curvature of an actual drill-hole path between two consecutive directional survey/orientation stations.

[00156] At the surface prior to obtaining the next orientation and core sample (or first if no previous core samples have been obtained for that drilling), a remote communication device (remote communicator) is set by an operator to a start time (say, T minutes).

[00157] The remote communicator communicates with the core orientation device and the core orientation device is then inserted into the drill hole.

[00158] After the set period of time (say, 'T' minutes) has elapsed the core orientation device will begin normal operation to detect the signature of vibration indicating a core break.

[00159] Alternatively, pressure changes or levels may be detected to indicate a pre-break condition or period, such as pressure of mud/water within the inner tube increasing due to the core filling or nearly filling the inner tube holding the core.

[00160] The core orientation device preferably does not take any orientation measurements while vibrations (e.g. due to drilling) are present. A combination of mechanical, electromechanical and/or electronic sensors and software algorithms programmed into the core orientation device determine that the core orientation device is in motion while descending down the hole and during drilling and is therefore not yet needed to detect breaking of the core sample from the body of material.

[00161] When ascending to the surface for core retrieval after core breaking ascending, the core orientation device also preferably does not take any core orientation measurements.

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[00162] If any measurements are taken during descending or ascending, due to sensitivity limitations of the sensors or during erratic silence segments, such measurements are discarded as they don't match the correct signature.

[00163] When the drilling ends and the driller is ready to break the core, the driller instructions will be to observe a period of Y seconds silence (no rotation), (this may typically be greater than 10s but no longer than 90 seconds). An Orientation & dip measurement will be taken during this period of silence. After breaking the core (breaking core operation should take less than, say 'X' seconds, which is typically X = 20s). Then the driller must wait, say 'Z' seconds silence (no rotation), (Z typically is greater than 90s). The purpose of these timings is to produce the correct 'signature'. If one of these criteria is not met then the sample can be discarded.

[00164] Alternatively or in addition, pressure created within the borehole by 'mud and/or water (which may be pumped down the borehole from the surface) may be detected. One or more forms of the present invention may include detecting that pressure reaching a certain pressure. One or more pressure sensors may be provided on the drillstring, such as on the inner and/or outer drill tube or on the drill bit or on the core orientation data recording device. Detected pressure (such as pressure within the inner tube receiving the core) or pressure differential (such as pressure differential between/across the inner and outer tubes, may be indicative of the inner tube being nearly or totally full of core. This occurs before the core is separated from the subsurface body of material (such as by breaking the core from the body by a sharp pull back on the core) and hence provides a 'signature' or indicator that the core is about to be broken.

[00165] For at least one preferred embodiment as shown in the flowchart in Figure 2, core orientation to be validated by the correct 'signature' can best be described when:

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a) 100 : Vibration above a threshold is not detected by the core orientation device, or is detected to be below a threshold, for period Y

b) 120: Core orientation measurement is taken during the 'vibration silence' period Y

c) 130: Followed by detection of noise from breaking the core from the subsurface body during a period X

d) 140: Followed by no detection of noise above a threshold, or is detected to be below a threshold, for period Z

e) 150: Orientation measurement is only retained if the above are present.

f) 160: The core orientation device can be configured to disregard detected signals or to not detect vibration or lack of vibration if & only if a, c, d above are present. If so, a fresh vibration silence signal 180 must then be detected before the core is broken.

g) 170: Optionally, dip measurement can be obtained during the period of no drilling prior to breaking the core (period Y), preferably if dip is within the set limits.

[00166] Once the required core orientation is obtained, the core orientation device may be shutdown or turned to low power standby mode 190 in preparation to be put into orientate mode 210 again.

[00167] Once the core orientation device is retrieved to the surface 200, an operator can set the device to an orientate mode 210. This can be done via the remote communication device communicating with the core orientation device 220.

[00168] The core orientation device can include one or more lights or other visual indicators, such as one or more display panels to give an indication of orientation direction and required orientation for marking the core.

[00169] According to one or more embodiments of the present invention, once in orientate mode, visual indications, such as flashing of one or more LEDs, will

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indicate to the operator which direction to rotate the core to find the correct 'down side' for marking. The correct downside is the part of the core that was lowermost prior to separating from the subsurface body.

[00170] Once correct downside is identified 230, the operator will again effect communication to the core orientation device via the remote communication device. The remote communication device will then verify 240 that the correct orientation was achieved (based on the orientation data recorded) and then preferably permit the operator to perform another orientation operation if so desired 250.

[00171] Optionally dip angle can be included in determining orientation of the core. The dip angle of the drill hole may be used to determine whether or not to use the orientation data obtained. For example, a correct core orientation sample may be determined from the aforementioned 'signature' steps being acceptable and the dip angle of the drill hole must also be within acceptable limits.

[00172] According to at least one particular embodiment of the present invention, the dip is sampled as a reference prior to the first run of a new drill hole. This is regarded as a setup function.

[00173] A setup function can be selected on the remote communications device which then communicates to the core orientation device. For clarity, the core orientation device does not orientate the core, rather, it records signals indicative of the orientation of the core to be retrieved. The core orientation device is then lowered down the hole or aligned to the angle of the drill rods in the case of no hole yet to be drilled.

[00174] Once the core orientation device is down to the end of the hole the user will 'mark' the 'shot', preferably via use of the remote communications device.

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[00175] The core orientation device is then retrieved and the remote communications device communicates to the core orientation device so that the core orientation device knows the dip (angle) of the drill hole.

[00176] Alternatively, the dip of the end of the hole can be manually entered into the remote communications device and this communicated back to the core orientation device.

[00177] For subsequent recordal(s) of orientation data after the first i.e. whenever a required subsequent signature occurs, and when the dip value is used, the dip is measured and if second dip value (D2) equals dip value 1 (D1)+/- E (where E typically equals 1.1) , the original signature data is retained. If D2 falls outside of D1+/-E, D2 is disregarded or discarded. The core orientation device will only store in memory values relating to the first signature.

[00178] For any subsequent run e.g. when the third signature occurs, if D3 = D2 +/- E the new signature is retained, otherwise it will be discarded if it falls outside of the required range. Only first compliant signature will be retained, etc.

[00179] One or more embodiments of the present invention may utilise the final compliant signature instead of the first compliant signature. A compliant signature is obtained when one or more signals indicative of the orientation of the core is/are obtained by the core orientation device during a period of no drilling vibration prior to detecting vibration from breaking the core and that being prior to a subsequent period of no drilling vibration.

[00180] In figures 3 and 4, a known prior art inner tube assembly 310 replaces a standard greaser with a two unit system 314,316 utilising a specialised greaser unit 314 and electronics unit 316 particular to the two unit system. The electronics unit is sealed to the greaser unit by o-rings, which have a tendency to fail in use and allow liquid into the electronics unit, risking loss of data and/or display failure. The electronics unit has an LCD display 318 at one end. This

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allows for setting up of the system prior to deployment and to indicate visually alignment of the core sample when retrieved to the surface. The greaser unit is connected to a backend assembly 320 and the electronics unit 316 is connected to a sample tube 322 for receiving a core sample 324. The electronics unit is arranged to record orientation data every few seconds during core sampling. The start time is synchronised with actual time using a common stop watch. The units are then lowered into the drill string outer casing to commence core sampling. After drilling and capturing a core sample in the inner core sample tube, the operator stops the stop watch and retrieves the core sample tube back to the surface. At the surface, before removing the core sample from the inner tube, the operator views the LCD display 318, if it is still working, which steps the operator through instructions to rotate the core tube 322 until the core sample 324 lower section is at the core tube lower end 326 . The core sample is then marked and stored for future analysis.

[00181] Referring to figure 4, the known electronics unit 316 of figure 3 includes accelerometers 328, a memory 330, a timer 332 and the aforementioned display 318.

[00182] The system 340 according to an embodiment of the present invention will hereinafter be described with reference to figures 5A to 8.

[00183] An outer drilling tube 334 consisting of connectable hollow steel tubes 334a-n has an extension piece 336 connected inline between two adjacent tubes in order to compensate the length of the outer drilling tube in relation to the additional length gained by the inner tube assembly 340 due to the core sample orientation data gathering device 342.

[00184] The core sample orientation data gathering device 342 is a fully sealed cylindrical unit with screw threads at either end. A first end 344 connects to a standard length and size greaser unit 346 and a second end 348 connects to a

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core sample tube 350. The greaser unit connects to a standard backend assembly 320.

[00185] There are no LCD display panels, indicators or switches mounted on the device. LED indicators are provided at one end 344, the greaser end, that are used in determining correct orientation of the core sample once the core and the device are recovered back a the surface. Figure 9 shows an example of the indicator end 344 of the core sample orientation data gathering device 342.

[00186] In figure 7, the core sample orientation data gathering device 342 is shown in close up. The end 344 for connecting to the greaser unit 346 includes a window (not shown in figure 7 - see figure 9). One or more LED lights are provided sealed within the device 342 behind the window. A coloured light indication is given to indicate which way (clockwise or anti-clockwise) the device 342 must be rotated to obtain a desired orientation of the core sample still within the inner tube assembly that is connected to the core sample orientation data gathering device 342. For example, a red light may be given to indicate to rotate the device (and thus the core sample) anticlockwise or to the left, and a green light may be given to indicate to rotate the device clockwise or to the right. A combined red and green indication, or a white light indication, or other indication can be given, such as flashing lights, to indicate that the core sample is correctly orientated and ready for marking.

[00187] Figure 8 shows an embodiment of the hand held device 360 which receives wirelessly receives data or signals from the core sample orientation data gathering device 342. The core sample orientation data gathering device 342 includes a transmitter which can use line of sight data transfer through the window, such as by infra red data transfer, or a wireless radio transmission. The communication device 360 can store the signals or data received from the core sample orientation data gathering device 342. The communication device 360 includes a display 362 and navigation buttons 364,366, and a data accept/confirmation button 368. Also, the hand held device is protected from

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impact or heavy use by a shock and water resistant coating or casing 370 incorporating protective corners of a rubberised material.

[00188] Setting up of the device is carried out before insertion into the drill hole. Data retrieval is carried out by infra red communication between the core sample orientation data gathering device 342 and a core orientation data receiver (see figure 6) or communication device 360. After recovering the core sample inner tube back at the surface, and before removing the core sample from the tube, the operator removes the 'back end assembly, and the attached greaser unit. The operator then uses the remote communication device to obtain orientation data from the core sample orientation data gathering device using an line of sight wireless infra red communication between the remote device and the core sample orientation data gathering device. However, it will be appreciated that communication of data between the core sample orientation data gathering device 342 and the communication device 360 may be by other wireless means, such as by radio transmission.

[00189] The whole inner tube 350, core sample 352 and core sample orientation data gathering device 342 are rotated as necessary to determine a required orientation of the core sample. The indicators on the greaser end of the core sample orientation data gathering device 342 indicate to the operator which direction, clockwise or anti-clockwise, to rotate the core sample. One colour of indicator is used to indicate clockwise rotation and another colour to indicate anti-clockwise rotation is required. This is carried out until the core sample is orientated with its lower section at the lower end of the tube. The core sample is then marked for correct orientation and then used for analysis.

[00190] As shown in figure 9, the indicator window end 344 of the core sample orientation data gathering device 342 includes a window 372. The indicator lights can be seen through this window at least when illuminated. In this embodiment, two lights, red and green LEDs are shown. The left hand 374 (red) LED illuminates to indicate to a user to rotate the device 342 anti-clockwise. The right

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hand 76 (green) LED illuminates to indicate to a user to rotate the device 342 anti-clockwise. When correct core sample orientation is achieved, both LEDs might illuminate, such as steady or flashing red and green, or another illuminated indication might be given, such as a white light (steady or flashing).

[00191] The visual and/or audible indicators, under certain site and/or environmental conditions, may not be sufficiently visible or audible. They may be hard to see in bright light conditions or hard to hear in loud working environments. Thus, an additional or alternative means and/or method may be utilised to ensure that the core sample has been correctly orientated. The outer casing or body or an end of the core sample data gathering device 342 may have angular degree marks. These may be scribed, etched, machined, moulded or otherwise provided, such as by printing or painting, on the device 342. For example, as shown in figure 9 dashes equally spaced around the outside parameter (each representing one or more angular degrees of the full circle or perimeter). Further scribing of a number every five dashes starting with the number "0" then 5, 10, 15 etc. until 355. When the core is retrieved and the orientation device communicates with the hand held communicator 360, additional information is transmitted from the orientation device to the communicator 360, such as a number between Zero and 359 (inclusive) denoting an angular degree of rotation of the core sample orientation data gathering device and the core sample. When the core is oriented during one or more embodiments of the method of the present invention, scribing on the core sample orientation data gathering device 342 number on the top side should be the same as the number transmitted to the communicator 360, which re-confirms correct orientation. Thus, if the visual or audible means for indicating core orientation are not useful or available, then the core is oriented using the angular degree arrangement (top side) to match the number transmitted, and then this would be audited using the communicator 360 as is the case now.

[00192] The core sample orientation data gathering device of the present invention is hermetically sealed against ingress of water or other liquids, even at

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operative borehole depths and conditions. No additional or alternative sealing, such as separate o-ring seals between the greaser and core sample orientation data gathering device or between the inner core tube and the core sample orientation data gathering device are required. Thus, maintenance or risk of ingress of liquid are not of concern.

[00193] Additionally, only the greaser needs to be separated from the core sample orientation data gathering device in order to obtain access and communicate with the device to obtain core orientation data. Likewise, setup prior to deployment is improved in terms of time and ease of use by not requiring a specialised back end assembly, rather, a standard greaser and back end assembly is used. This also improves compatibility with standard systems.

[00194] Obtaining core orientation is made easier by only requiring two colours lights to indicate one or other direction of rotation to establish correct core orientation prior to marking. The indicators form part of the sealed device and can be low power consumption LED lights. Alternatively, flashing lights may be used. For example, a certain frequency or number of flashes for one direction and another frequency or number of flashes for the other direction of rotation. A steady light could be given when correct orientation is achieved.

[00195] Confirmed correct core alignment is registered in the remote communication device 360. This provides for an audit trail, and the data can be readily transferred to computer for analysis and manipulation. This also provides reassurance of accuracy of sampling and orientation to operators, geologists and exploration/mining/construction companies.

[00196] In use, the core inner tube 350, data gathering device 342 and greaser 46 are connected together in that order and lowered into a core sampling outer tube having an annular diamond drill bit at the furthest end. Once a core sample is obtained, the inner tube assembly with the data gathering device and greaser are recovered back to the surface, the back end assembly 320 and greaser are

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