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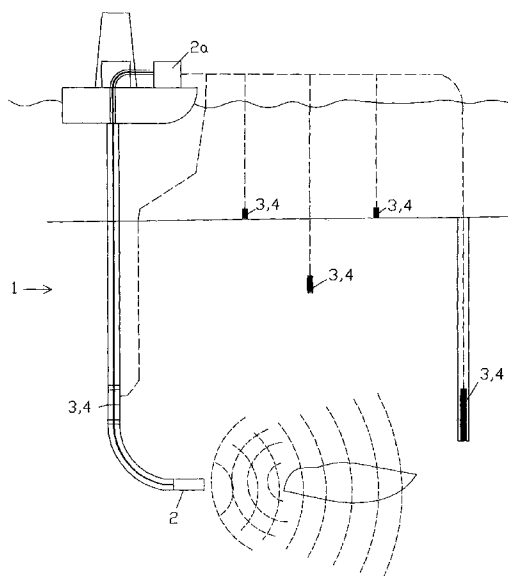


Fig. 1

(57) Abstract: Assembly for drilling and logging, comprising a device for electro pulse drilling (EPD device), at least one device
to receive acoustic signals generated by the EPD device, distinguished in that the assembly further comprises at least one device to
receive electromagnetic signals generated by the EPD device. Method for drilling and logging, and device for electro pulse drilling.

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Assembly for drilling and logging, method for drilling and logging and device for electro pulse drilling

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Field of the invention

The present invention relates to drilling and logging, particularly for exploiting hydrocarbons from underground formations.

More specifically, the present invention relates to an assembly for drilling and logging, a method for drilling and logging and a device for electro pulse drilling particularly feasible for working the method.

Background of the invention and prior art

Most deposits of gas and/or liquid hydrocarbons are found hidden inside the underground in strata of rock sediments. Drilling into the underground to be able to produce hydrocarbon fluids from a hydrocarbon-containing formation, is very costly. To increase the possibility for the well to hit a hydrocarbon containing reservoir, the underground is mapped as much as possible before drilling. Seismic techniques, and to a lesser extent electromagnetic techniques are used for said mapping.

But also during drilling there is great interest in having information on the underground in order to have better planning and control of the drilling operation so that assumed or identified hydrocarbon reservoirs can be produced. Advantageously, said information is as detailed and correct as possible, for improved planning and control of the drilling operation.

Drilling is usually performed with a drill string that is rotated from the surface. An alternative method is to use a down-hole motor near the drilling bit, for rotation thereof. The motor can for example be driven by the circulating drilling mud.

A third method for drilling is electro pulse drilling, so-called EPD- Electro Pulse Drilling. When electro pulse drilling, powerful electric pulses are used to break up the formation, instead of a pure mechanical treatment as used by the traditional drilling processes. More specifically, at least two electrodes that are separated with an insulating material are used, one electrode being charged to a high electrical potential, while the other electrode is grounded. At sufficiently high charging, a powerful spark will be formed as the electrodes are short-circuited by the current going the way of lowest resistance from the charged electrode to the grounded electrode. A drill bit for electro pulse drilling comprises at least said two types of electrodes, in different configurations, and may in addition comprise one or several additional electrodes that during operation will take potential between said electrodes, so-called floating electrodes. There is a requirement for high voltage, typically several kilovolts, and high

current to deliver sufficient energy to break up the formation ahead of the drilling bit where the electrodes are arranged. To have sufficient effect, at power-full electric supply is required, typically comprising a number of elements for charging and subsequent discharging of the electrical energy, which elements typically are in the form of condensers. Dependent on the formation and the operational parameters, the electrical spark will form a pressure wave in the drilling fluid ahead of the drilling bit, or form a plasma channel in or at the formation, in both circumstances resulting in breaking up of the formation.

Electro pulse drilling is described in several patent applications, of which three are described below.

In patent publication US 4,741,405 a device is described for focused electro pulse drilling, comprising multiple electrodes. The drill bit includes at least a first electrode that is positively coupled to a pulse-forming line, a second electrode that is coupled to the ground potential, and a number of third electrodes that are arranged near the first and the second electrode, the third electrodes being floating electrodes. By charging the first electrode, at the correct conditions a spark will be formed between the first electrode and one of the third electrodes, further to a next of the third electrodes, until the spark finally goes over to the grounded second electrode. The drill bit is against the formation surrounded by a working fluid, and the sparks form a pressure wave in the working fluid directed at the material to be drilled out. It is assumed that in the working fluid plasma channels are formed, resulting in pressure waves, which again have sufficient energy to break down the material to be drilled out. By a sophisticated switched coupling of the pulse-forming lines between an electric supply and selected first electrodes in the drill bit, a focusing of the pressure wave can be achieved, such that the drill can be controlled and directed. The high-voltage power can be delivered to the pulse-forming lines either down-hole or from the surface. A number of means to this end are described, amongst them use of a Marx-generator as high-voltage source. Further, it is described for example in column 4, lines 32-46 that the electro pulse drill as such can be used as a source for seismic impulses to determine the position of the drilling bit and thereby the position of the well-bore. More specifically, pressure waves generated by the drill bit are used as seismic impulses that can be received by a network of seismic receival units positioned on the surface close to the well-bore. Seismic time-distance data can be real-time processed, and a continuous presentation of the well-bore position and deviations from a normal can be projected by use of a dedicated unit. The deviations can then be used to correct and direct the drilling device by generating control signals from the surface. In the patent publication there is only a short description of seismic time/distance analysis to determine the position, nothing is mentioned about mapping formation properties based on the received seismic data or other data.

In patent publication RU 2167991 C2 electro pulse drilling is described in the form of rotational drilling with a mechanical tool, with high-voltage electric pulses traveling over the bottom of the well-bore to reduce the formation strength. Thereby a more effective drilling is achieved.

5 In patent publication WO 03/069110 A1 electro pulse drilling is described in the form of plasma channel drilling. More specifically, an apparatus and a method are described, using a pulsed high-voltage generator coupled to an electrode assembly placed at a material removal station for the apparatus, which means down into a well-bore, the apparatus being adapted to generate electrical pulses to form a plasma channel
10 repetitively per second within or on a surface of a material, so that material is removed by rapid expansion of each plasma channel that fractures and fragments the material body. 1-100 pulses per second are used, typically 5-25 pulses per second, lasting 1-50 micro seconds, and rise time below 150, typically below 100 nanoseconds, with high-voltage in the range 10-50 kV and effect with top value 1-100 MW. Voltage is limited
15 to about 50 kV to avoid too comprehensive requirements as to insulation. Holes can be drilled with diameters up to 100 mm. Drilling in a "dry" well-bore is also possible, see page 6, line 22, but preferably a drilling fluid of low electric conductivity is used, such as water, which is preferable for removal of fragments. The electrodes are concentrically arranged, with ground outermost. The publication provides a good and
20 comprehensive description of physical parameters in connection with electro pulse drilling. The significance of the dielectrical properties of fluid and formation ahead the drilling bit is described relative to different operating parameters. Inter alia, it is described that at relative high voltage, the electrical break-down will take place in the formation instead of in fluid surrounding the drilling bit. The figures 6 and 7 illustrate
25 break-down of the insulating dielectricum (either the formation that is drilled out or fluid surrounding the drilling bit) as function of voltage or voltage field, and time for discharging. Likewise, the significance of distance between the electrodes is illustrated and described. On page 16, lines 7-21, for operating parameters resulting in the electrical break-down in the formation instead of in a fluid, it is explained how the
30 plasma channels gradually will break down the formation over the whole area of the drilling bit in the direction of drilling, because the plasma channel seeks to go the way of lowest resistance, which way thereby will be the formation. The plasma channel formation will over time rotate 360° around the drilling bit face, whereby material ahead of the full drilling bit is broken down and there is no need to rotate the drill bit
35 with electrodes per se. Further, it is described that the pulse generator preferably can generate a high-voltage pulse with a wave-form near the critical damped response from the circuit formed when the plasma channel is produced. Formation of a plasma channel results in break-down of the dielectrical resistance, why next plasma channel formation should wait until the dielectrical resistance is reestablished. In the

publication there is no discussion of electro pulse drilling and simultaneous logging of any kind.

Measurement while drilling, MWD, means to collect data on pressure, temperature and path of drilling in three dimensions during or in connection with drilling. Measurements while drilling to map the formation itself is usually termed logging-while drilling, LWD, which includes measurement of parameters as resistance, porosity, acoustic velocity and gamma radiation. In Patent Publication US 5,881,310 a closer description of LWD and MDW is found. In said publication it is described that the drilling string and drill bit can be used as a source for acoustic signals, but electro pulse drilling is not mentioned.

In Patent Publication WO 2004/083898 A1 a method and an apparatus are described for determining the properties of underground reservoirs by using an electromagnetic transmitter and a seismic transmitter with in substance identical location on the ground or seabed, which transmitters generate signals that are received by an electromagnetic receiver and a seismic receiver, said receivers having in substance identical location on the ground or seabed, separated from the transmitters. Preferably low acoustic and electro magnetic frequencies are used, in the range 0,1 to 20 Hz, to have reach. By analyzing and comparing different components of electromagnetic field and acoustic response, particularly refracted components, data indicating presence of a hydrocarbon reservoir can be identified and analyzed.

In Patent Application WO 02/14906 A1 a method and an apparatus is described for determining properties of underground reservoirs. An electromagnetic field is applied from the seabed by use of a dipole antenna-transmitter, which field is detected by using a dipole antenna-receiver. Measurements are taken with the antenna-receiver both in-line and parallel and the difference between the two sets of measurements give indication of interest. Dependent on the angle of incidence and state of polarization an incident electromagnetic wave to a layer of high resistance may excite a ducted or guided wave mode in the layer. Such high-resistive layer can be a hydrocarbon-containing layer. The ducted wave modus propagate laterally along the layer and leaks energy back to the overburden and receivers positioned on the seabed. The ducted wave-modus is excited only for an incident wave with transverse magnetic (TM) polarization, which means magnetic field perpendicular to plane of incident, and at angles of incidence close to the Brewster angle and the critical angle (the angle of total reflection). For electromagnetic waves with transverse electric polarization (TE) the ducted mode will not be excited. The transmitter generates both TE and TM waves, but by varying the orientation of the transmitter, optionally using orthogonally oriented receiver antennas, the two modes of waves can be received at different sensitivity.

The above-mentioned methods for mapping the underground are comprehensive and expensive. Often the signals are noisy due to interference and

interaction, inter alia, with other sources, long path of the signal, and problems with weak contact with the seabed and disturbing effects of surrounding seawater. There is a demand for better technology for logging, particularly at simultaneous drilling, and particularly so that comprehensive quantities of data of preferably independent data can be collected. There is also demand for a device for electro pulse drilling that is particularly feasible for simultaneous electro pulse drilling and generation of signals for logging.

The objective of the present invention is to meet the above demands.

Summary of the invention

With the present invention an assembly for drilling and logging is provided, comprising a device for electro pulse drilling (EPD device) and at least one device for receiving acoustic signals generated by the EPD device, distinguished in that the assembly further comprises at least one device for receiving electromagnetic signals generated by the EPD device. With acoustic signal is meant any type of elastic or seismic signal generated by the EPD device. By electromagnetic signals is meant any type of electric, electromagnetic and magnetic signals generated by the EPD device.

With a device for electro pulse drilling is meant any device for electro pulse drilling, for example those introductorily described, but more preferably a device for electro pulse drilling in accordance with the present invention, which will be further described below. The devices to receive acoustic and electromagnetic signals respectively, generated by the EPD device are of any previously known type, and with placement feasible to receive said signals.

The assembly according to the invention preferably comprises acoustic receivers measuring three displacement vectors and one pressure component, the receivers being arranged in one or more positions chosen amongst: on a seabed, on a ground surface, in water over the seabed, in one or more separate well-bores, in the well-bore where the EPD device is used. Thereby the shear and pressure components of the acoustic waves can be determined. Conveniently, three-axial piezoelectric receivers, hydrophones and geophones can be used.

The assembly according to the invention preferably comprises electromagnetic receivers, arranged in one or more positions chosen amongst: on a seabed, on a ground surface, in water above the seabed, in one or more separate well-bores, in the well-bore where the EPD device is used. With the term electromagnetic receiver is meant electric field receivers, electromagnetic receivers and magnetic field receivers. Electric field receivers comprise for example different types of electrode antennas, such as silver-silver-chloride-, carbon-filled electrodes, fiber optic sensors, dipole antennas and dielectric plate antennas. Electromagnetic receivers comprise for example ring antennas and coils with or without ferromagnetic core, and induction coil magneto-

meters. Magnetic field receivers can be divided into two main groups: 1) magnetometers for $H < 1\text{mT}$ and 2) Gauss meters for $H > 1\text{mT}$. Magnetometers can be divided into two subgroups: a) vector, for example search coil, fluxgate, squid, magneto-resistive and fiber optic magnetometers, and b) scalar, for example optic pumped and proton precision magnetometers. Gauss meters are for example Hall effect-magneto-resistive, magneto-diode, and magneto-transistor Gauss meters. The receivers can preferably be arranged in pairs and three and three to measure all components of the electromagnetic field. Most preferred are silver-silver-chloride dipole electrodes or coils with ferromagnetic core for measurement of electric and magnetic field strength on the surface, respectively, because of simple production, low cost and good measurements. In well-bores ring antennas, such as loop antennas or circular antennas are most preferred for electromagnetic measurement, for corresponding reasons. The above-mentioned receivers are preferably placed together in groups, so that several types of measurement can be made from the same position, which simplifies analysis of the measures data. Further, many groups of receivers are advantageously arranged, particularly on the seabed, to provide several sets of measurements and good positional accuracy. The receivers generate advantageously electrical, acoustic, radio, electromagnetic or optical signal that are delivered in the form of raw data or processed data via cable or by other means to a surface position, preferably readable and processable in real-time. In the well-bore where the EPD device is used, receivers are preferably arranged in pairs, for example close to each other along a drill string and in addition diametrically opposite about a drill string, for easier to identify and remove unwanted signals, and determining the position of interesting reflexes or signals. The measurement devices measure strings of data over time at a frequency of measurement adapted relative to the frequency of the generated waves.

The assembly according to the invention preferably comprises a device coupled to the receivers for recording, storage and processing of data from the receivers connected to the EPD device or readable for an operator of the EPD device, for control of the electro pulse drilling based on measured and/or processed data, either manually or automatically.

The assembly according to the invention preferably comprises an EPD device with adjustable effect, so that the plasma generation selectable can be provided either in a drilling fluid ahead of the drill bit, or into or on a formation surface in front of the drill bit. This is of significance not only for the drilling process and the control thereof, but also for the generation of different types of data. There are reasons to expect that plasma channel formation in or on the formation will give different electromagnetic and acoustic signature than plasma channel formation in a drilling fluid. The plasma channel formation in a drilling fluid gives a pressure wave and an electromagnetic wave which because of reflection at the interface to the formation are assumed to have

lower penetration into the formation, and a different content of shear and transverse components for the generated wave fields, than plasma channel formation into (and possibly onto) the formation. Further, the output effect for plasma channel formation in a drilling fluid will be lower, and the physical mechanism for the way in which the formation is fragmented will be different.

The assembly according to the invention preferably comprises a device for electro pulse drilling with at least three electrodes for charging to high-voltage (charging electrodes) and subsequent discharging, arranged angularly separate within the circumference, at least one electrode coupled to ground, as the electrodes are arranged in a drilling face of a drilling bit, with insulation between electrodes, with individually switch-able connection of charging electrodes to an effect-selectable high-voltage source. With at least three charging electrodes, preferably arranged evenly around the circumference, and with a selectable effect for the high-voltage source that can be controlled to provide plasma channel formation either into or onto the formation or within a drilling fluid, both improved control of the device for electro pulse drilling and generation of different types of acoustic and electromagnetic signals are achieved. The frequency of the generated wave field can be controlled by the switching.

The invention also provides a method for electro pulse drilling and logging, comprising introducing a device for electro pulse drilling in a well-bore, either in the end of a drill string or in the end of a cable or a coiled tubing, distinguished by electro pulse drilling the formation while simultaneously generating electromagnetic and acoustic signals; to receive acoustic signals with at least one device for receiving such signals, to receive electromagnetic signals with at least one device to receive such signals, and to use the received data, either directly or in processed form, to control the electro pulse drilling.

Eventually, the invention provides a device for electro pulse drilling, distinguished in that it comprises at least three electrodes for charging to high-voltage (charging electrodes) and subsequent discharging, arranged angularly in separated sectors within the circumference, and at least one electrode coupled to ground, the electrodes being arranged in a drilling face in a drilling bit, with insulation between electrodes, with individual switch-able coupling of charging electrodes to a high-voltage source for which the effect can be selected.

The present invention has benefits by the source for signals for logging simultaneously being the device for drilling, and the generated signals travel a shorter way than if they were generated at the surface, which provides lower damping and less occurrence of disturbing signals. Further, from one source independent signal can be provided in the form of acoustic and electromagnetic signals, and the electromagnetic and acoustic signals can be generated by different operating parameters and provide independent sets of measurements. Thereby, at a relative low cost a large quantity of

data of identical and/or independent measurements can be provided, which provides data of good statistical significance. It is possible to work the invention by using only previously known equipment.

5 **Figures**

The present invention is illustrated with three figures, more specifically Figure 1 that illustrates an assembly according to the invention,

Figures 2A and 2B that illustrate the device for electro pulse drilling according to the invention, and

10 Figure 3 that is a cross-section illustrating arrangement of receiving devices and the EPD device of the assembly and the method according to the invention.

Detailed description

Figure 1 illustrates an assembly 1 according to the invention, comprising a
15 device 2 for electro pulse drilling (EPD device), at least one device 3 to receive acoustic signals generated by the EPD device, and at least one device 4 to receive electromagnetic signals generated by the EPD device. The devices 3, 4 to receive acoustic and electromagnetic signals, respectively, are operatively coupled to a unit 2a that receives and processes the signals, for use either manually or automatically to
20 control the electro pulse drilling based on the measured data. Thereby the electro pulse drilling can be controlled to hit and penetrate a hydrocarbon reservoir, as the measured data can provide information on the location of the drill relative to said reservoir. To achieve the best functionality it is required with an EPD device that is particularly feasible to provide measurement data of sufficient quality to delimit and determine a
25 hydrocarbon reservoir. Such EPD device is provided with the invention and is illustrated on the Figures 2A and 2B.

More specifically, Fig. 2A illustrates a device 2 for electro pulse drilling, comprising three electrodes 2B for charging to a high-voltage (charging electrodes) and subsequent discharging, arranged in angularly separated sectors within the
30 circumference and at least one electrode 2c coupled to ground, the electrodes being arranged in a drilling face 2d of a drill bit, with insulation between electrodes, with individually switch-able coupling of charging electrodes to a effect-adjustable high-voltage source 2e. Three charging electrodes 2b are illustrated, arranged 120° separated within the circumference of the drilling face 2d. This is sufficient to be able to focus
35 the electro pulse drilling in any direction, by alternately charging charging-electrodes to have the electro pulse drill deviating in the desired angle. However, to increase the diameter of the well-bore and drilling face area, and steer-ability, it can be preferable with four charging electrodes or more, arranged within the circumference of the drilling face, as illustrated on Figure 2B. The drill bit for electro pulse drilling

illustrated on Fig. 2B comprises in total 8 charging electrodes and two concentric grounded electrodes. The drilling face also comprises insulation 2f between the electrodes, and openings 2g for circulation of drilling fluid. The electrodes are coupled with pulse-forming lines 2h to an electric supply 2e, which again is coupled to a unit 2a for receival and processing of data from receivers for electromagnetic and acoustic signals generated by the EPD device, as apparent from Figure 2A. The figures are not drawn to scale and all reference signs are not introduced, to improve clarity. The electric supply 2e can deliver charging that provides plasma channel forming only in or on the formation and charging that provides plasma channel formation only into the drilling fluid ahead of the drill bit, and be adjusted for aimed focusing of the drilling effect. Said focusing is achieved by choosing charging electrodes or sections or groups of charging electrodes so that the drilling effect is angularly focused in the desired direction, by the electro pulse drill not drilling at even rate over the drilling face. For example when drilling in sandstone, and with 5 cm between the electrodes, a charging up to at least 250 kV is required for plasma channel formation to take place into or on the sandstone instead of into a drilling fluid of water, according to Fig. 6 of Patent Publication WO 03/069110. By focused drilling in sandstone a charging is therefore elected to be below 250 kV, and electrodes providing desired deviation of the drilling direction. In the introductorily described patent application WO 03/069110, further guidance is found on appropriate operating parameters, refer in particular to the figures 6-8 and accompanying text in the description. The electric supply can conveniently be an adapted Marx generator. The pulse-forming lines can conveniently be Blumlein pulse-forming lines. The charge voltage can preferably be adjustable from 0 to at least 300 kV, most preferably so that plasma channel formation can take place in any type of formation that is drilled through at the actual distance between the electrodes. The insulation between the electrodes is conveniently in the form of a ceramic material. Further guidance on pulse-forming lines, electric supply, charge voltage and effect of electrode separation can be found in Patent Publications WO 03/069110 and US 4,741,405.

Fig. 3 is a cross-section illustrating the arrangement of receiving devices and the EPD device of the assembly and the method according to the invention. A substantial number of receiving devices 3, 4 are illustrated, which receiving devices in general are a group of receiving devices chosen amongst acoustic and electromagnetic receiving device. More specifically, the receiving devices 3, 4 are arranged in the sea 5 above a seabed 6, on said seabed 6, in geological strata 7, 8, and 9 downward from the seabed in separate well-bores and in the well-bore 13 where the EPD device is used. Under a cap 10 gas 11 and oil 12 are found. With the EPD device 2 the well-bore 13 is drilled further so that the well-bore 13 hits said gas and oil, for subsequently to produce the gas and oil through the well-bore.

The EPD device will during operation generate acoustic and electromagnetic waves, of frequency determined by the switching and discharging frequency, and energy and component contents dependent on the discharging effect and modus for plasma channel formation (in a drilling fluid, or in or on a formation). More specifically the acoustic waves will comprise both pressure and shear components, and the electromagnetic waves will comprise TE and TM components. The EPD device will initially send out a short response with random shape limited in time and as a continuous frequency spectrum of acoustic and electromagnetic waves, which results in time-domain data. Transmission of long periodic signals in time from the EPD device results in principle in discontinuous frequency spectra, resulting in frequency-domain data. In principle it is the objective to use all types of data that can be generated by the EPD device, both time-domain data and frequency-domain data.

The receivers for acoustic and electromagnetic signals will receive a comprehensive set of signals with direct, reflected, refracted, deviated and excited components. Amongst the signals it will in particular be sought for components giving information suitable to delimit and determine the properties of interesting zones in the reservoir. Acoustic shear components, formed directly by the EPD device or by reflections, will to a limited extent propagate through fluid containing reservoirs, because fluids do not transfer shear waves. Fluid-containing zones, in particular zones containing oil and gas, will typically have a resistivity that deviates from the surrounding areas and the overburden. Electromagnetic TM components can, dependent on the angle of incidence, excite a channeled wave modus in a layer of high resistivity, as described in Patent Publication WO 02/14906 A1. Advantageously, many receivers are used, with different placements to provide good accuracy for determining positions by path-time analysis. The transmitter (EPD device) and receivers must be synchronized in real-time, for example with GPS, and the transfer function of the sender and the receivers must be measured or estimated. For receivers that store the signals preliminarily, time must be logged together with received data, in order to correct any time deviation. Further, measurements may advantageously be taken up over a drilling interval, in order to have components formed that are particularly feasible for determining the properties of the interesting zones. Advantageously, many measurements are taken to obtain data that can be processed by averaging and filtering away noise and undesired signal components as appropriate. Analysis and processing of the measured data is a comprehensive and challenging operation. Data can be analyzed by using existing techniques, as for example described in the Patent Publications WO 02/14906 A1 and WO 2004/083898 A1, and techniques being developed.

When drilling a well it can be preferable to use conventional drilling technology for the upper parts of the well bore, having larger diameter than achievable

with electro pulse drilling, but shifting to electro pulse drilling when the well-bore is close to an identified reservoir. To take up forces generated by the EPD device, and to ensure good access deeply into deviating well-bores, the EPD device can be arranged as a bottom hole assembly at the end of a drill string.

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Claims

1. Assembly for drilling and logging, comprising
5 a device for electro pulse drilling (EPD device),
at least one device to receive acoustic signals generated by the EPD device,
c h a r a c t e r i z e d i n that the assembly further comprises
at least one device to receive electromagnetic signals generated by the EPD
device.
10
2. Assembly according to claim 1,
c h a r a c t e r i z e d i n that it comprises acoustic receivers measuring three
displacement vectors and one pressure component, the receivers being arranged in one
or more positions chosen amongst: on a seabed, on a ground surface, in water above
15 the seabed, in one or more separate well-bores, in the well-bore where the EPD device
is used.
3. Assembly according to claim 1,
c h a r a c t e r i z e d i n that it comprises electromagnetic receivers, arranged in one
20 or more positions chosen amongst: on a seabed, on a ground surface, in water above
the seabed, in one or more separate well-bores, in the well-bore where the EPD device
is used.
4. Assembly according to claim 1,
25 c h a r a c t e r i z e d i n that it comprises silver-silver-chloride dipole electrodes and
coils with ferromagnetic core for measuring electric and magnetic signals respectively,
on the surface or a seabed.
5. Assembly according to claim 1,
30 c h a r a c t e r i z e d i n that it comprises loop antennas for measuring
electromagnetic signals in a well-bore.
6. Assembly according to claim 1,
c h a r a c t e r i z e d i n that it comprises a device coupled to the receivers for
35 recording, storing and processing of the data from the receivers, coupled to the EPD
device or readable for an operator for the EPD device, for control of the electro pulse
drilling based on the measures and/or processed data, either manually or automatically.
7. Assembly according to claim 1,

characterized in that it comprises a EPD device with adjustable performance, so that plasma formation selectable can be provided either in a drilling fluid ahead of the drilling bit, or into or onto a formation face ahead of the drilling bit.

5 8. Assembly according to claim 1,

characterized in that it comprises a device for electro pulse drilling with at least three electrodes for charging to a high-voltage (charging electrodes) and subsequent discharging, arranged angularly separate within the circumference, and with at least one electrode coupled to ground, the electrodes being arranged in a
10 drilling face of a drill-bit, with insulation between the electrodes, with individually switch-able coupling of the charging electrodes to an effect-adjustable electric high-voltage supply.

9. Method for electro pulse drilling and logging, comprising to bring a device for
15 electro pulse drilling into a well-bore, either in the end of a drill string or in the end of a cable or coiled tubing,

characterized by electro pulse drilling the formation by simultaneously generating electromagnetic and acoustic signals; to receive acoustic signals with at least one device to receive such signals; to receive electromagnetic signals with at least
20 one device to receive such signals; to use the received data, either directly or in processed form, to control the electro pulse drilling.

10. Device for electro pulse drilling,

characterized in that it comprises at least three electrodes for charging to a
25 high voltage (charging electrodes) and subsequent discharging, arranged in angularly separated sectors within the circumference, and at least one electrode coupled to ground, the electrodes being arranged in the drilling face of a drill bit, with insulation between the electrodes, with individually switch-able coupling of charging electrodes to an effect adjustable high-voltage source.

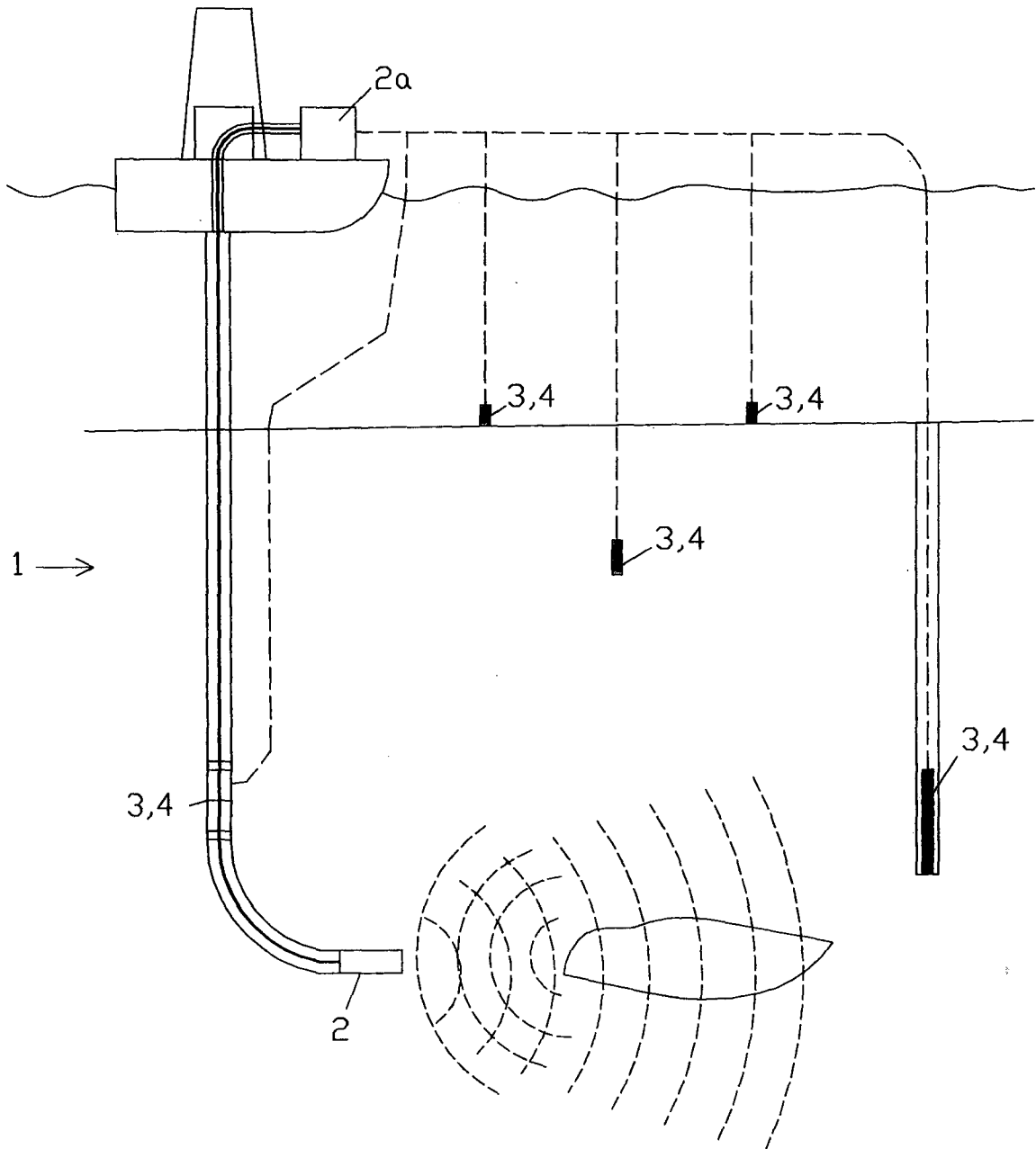


Fig. 1

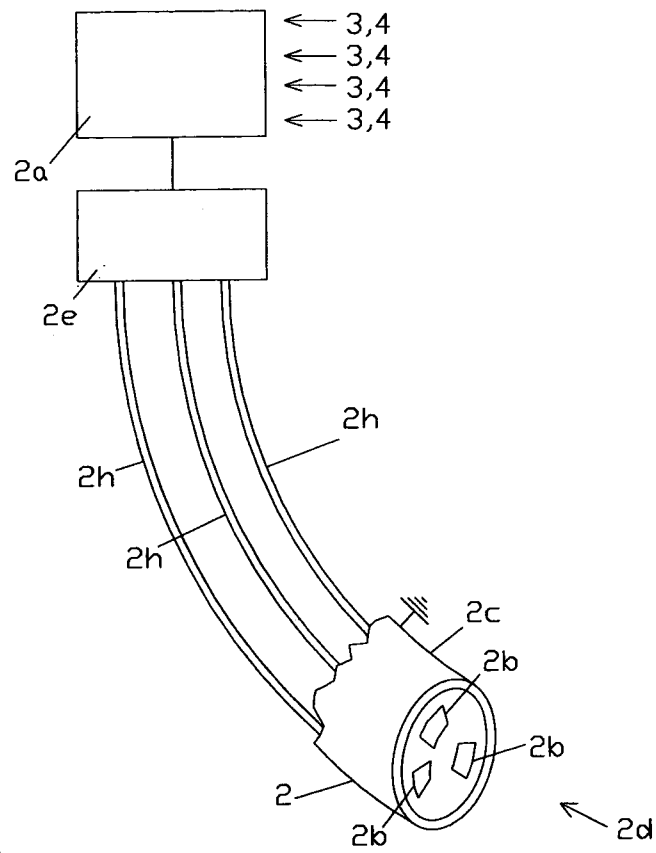


Fig. 2A

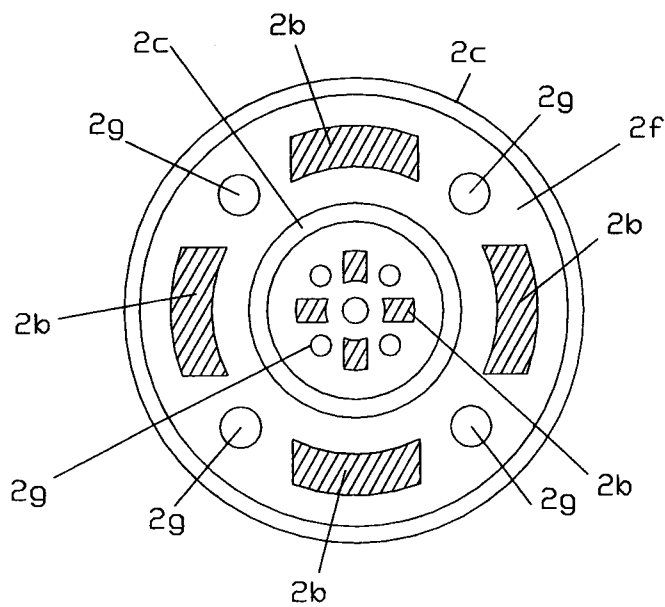


Fig. 2B

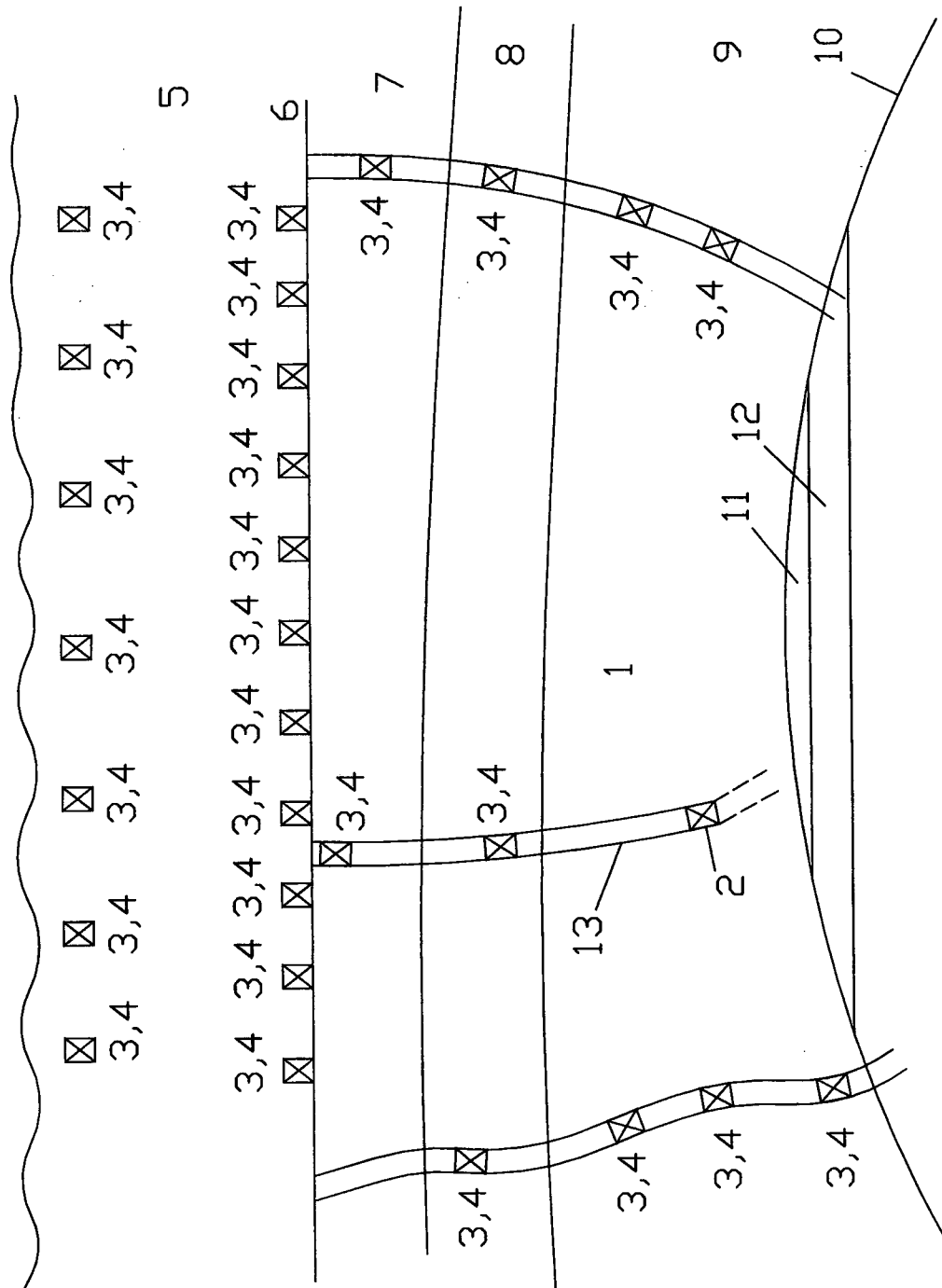


Fig. 3

INTERNATIONAL SEARCH REPORT

International application No.

PCT/NO2008/000042

A. CLASSIFICATION OF SUBJECT MATTER

IPC: see extra sheet

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC: E21B

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

SE,DK,FI,NO classes as above

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

EPO-INTERNAL, WPI DATA, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 4741405 A (W.M. MOENY ET AL), 3 May 1988 (03.05.1988), whole document	10
A	--	1-9
A	GB 2420358 A (SCHLUMBERGER HOLDINGS LIMITED), 24 May 2006 (24.05.2006)	1-9
A	--	
A	WO 2005054620 A1 (UNODRILL AS), 16 June 2005 (16.06.2005)	1-9
A	--	
A	WO 03069110 A1 (UNIVERSITY OF STRATHCLYDE), 21 August 2003 (21.08.2003)	1-9
	--	

☐ 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

27 May 2008

Date of mailing of the international search report

30-05-2008

Name and mailing address of the ISA/

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/NO2008/000042

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:

I: Claims 1-9 referring to an assembly and a method for drilling and logging, wherein seismic and electromagnetic signals resulting from electro pulse drilling (EPD) are used as signal source for acoustic signal receivers and electromagnetic receivers, respectively, and the signals from

.../...

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 an additional fee, this Authority did not invite payment of any additional fee.
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.

Box III

the receivers are used for logging purposes.

II: Claim 10 referring to a device for EPD, only, wherein the layout of the electrodes is specified.

As both the problems and solutions are technically different, no single general concept can be formulated based on the technical features of the inventions. Consequently, the requirements of Rule 13.1 PCT are not met.

It was investigated under Rule 13.2 if any further feature, either in the claims or derivable from the description, could be considered as a same or corresponding feature, and could be considered a special technical feature establishing a technical link between the (two) groups of inventions.

No such features were identified.

Consequently, the two groups of inventions are not so linked as to form a single general inventive concept as required by Rule 13.1 PCT.

International patent classification (IPC)

E21B 7/15 (2006.01)
E21C 37/18 (2006.01)
E21B 47/12 (2006.01)
G01V 11/00 (2006.01)

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

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- e-tjänster/anförda dokument (service in Swedish).

Use the application number as username.

The password is **ORILWZAEZV**.

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

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

INTERNATIONAL SEARCH REPORT

Information on patent family members

26/01/2008

International application No.

PCT/NO2008/000042

US	4741405	A	03/05/1988	NONE		
GB	2420358	A	24/05/2006	GB	0425312 D	00/00/0000
				NO	20072185 A	15/08/2007
				WO	2006054079 A	26/05/2006
WO	2005054620	A1	16/06/2005	EP	1711679 A	18/10/2006
				JP	2007527962 T	04/10/2007
				NO	322323 B	18/09/2006
				NO	20035338 A	02/06/2005
				RU	2006118141 A	10/01/2008
WO	03069110	A1	21/08/2003	AU	2003205873 A	00/00/0000
				EP	1413160 A	28/04/2004
				EP	1474587 A	10/11/2004
				GB	0203252 D	00/00/0000
				US	7270195 B	18/09/2007
				US	20050150688 A	14/07/2005