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

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
10 January 2008 (10.01.2008)

PCT

(10) International Publication Number
WO 2008/003994 A2

(51) International Patent Classification:
G01V 1/38 (2006.01)

(21) International Application Number:
PCT/GB2007/002573

(22) International Filing Date: 9 July 2007 (09.07.2007)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
0613540.4 7 July 2006 (07.07.2006) GB

(71) Applicant and
(72) Inventor: **TAURO, Peter, Francis** [GB/GB]; SLP Engineering Limited, Hamilton House, Battery Green Road, Lowestoft, Suffolk NR32 1DE (GB).

(74) Agent: **I.P. 21 LIMITED**; Norwich Research Park, Colney, Norwich NR4 7UT (GB).

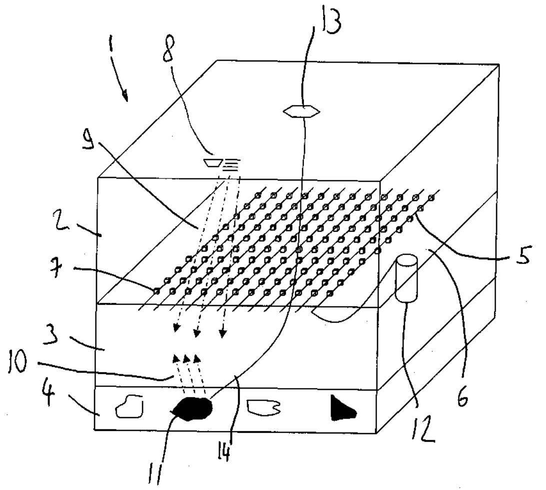
(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, 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:
— *without international search report and to be republished upon receipt of that 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: RESOURCE EXTRACTION MODELLING SYSTEMS AND/OR METHODS



(57) Abstract: A resource extraction modelling system, comprises: • an array of seismic cables; • a plurality of spaced apart sensors located on said cables; said cables being located below the surface of the seabed or sufficiently adjacent to a seabed for receiving signals reflected from a region for potential resource extraction located underground; • a mobile signal generator displaced by a vessel in order to sweep a region for potential resource extraction; said signals being reflected from said underground region for potential resource extraction and sensed by said sensors; • means for transmitting signals to an analysis location; • means for converting received signals into a volumetric model for identifying the configuration of said region for potential resource extraction; • means for selecting a virtual drilling and/or extraction structure with predetermined properties from a bank of a plurality of virtual drilling and/or extraction structures; and • means for calculating values representative of the operation of said selected drilling and/or extraction structure at a particular location for resource extraction.

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Resource Extraction Modelling Systems and/or Methods

Field of the Invention

The invention relates to resource extraction modelling systems and/or methods for modelling resource extraction.

Background to the Invention and Prior Art known to the Applicant

It is known to generate on a flat computer screen maps of a potential resource extraction region, which appear to the eye as three-dimensional. The known method of generating such maps employs an array of seismic cables located on the seabed. The sensors located on the cables sense signals reflected from the potential resource extraction region. The distortion of the received signal is dependent upon the particular configuration of the resource extraction region. For example, the signals received for the presence of gas can be distinguished from the signals received for the presence of oil at a particular location within the region. The accuracy of such a system is achieved through known computer iterative technology. Once the three-dimensional map is produced, the drilling operation is immediately initiated in regions, which appear to be favourable for exploration.

In practice, numerous drilling attempts are carried out until an appropriate source location is established for the mounting of a resource extraction platform or the like. The drilling process is labour-intensive and overall expensive particularly due to the requirement of having to carry out multiple exploratory drilling operations.

Any incremental improvement in the efficiency of the location of an initial drilling and extraction site results in considerable benefits in overall productivity, reduction of set up time for resource extraction, and for the environment since any wastage due to failed drilling operations.

Summary of the Invention

In a first broad independent aspect, the invention provides a resource extraction modelling system, comprising:

- an array of seismic cables;
- a plurality of spaced apart sensors located on said cables; said cables being located below the surface of the seabed or sufficiently adjacent to a seabed for receiving signals reflected from a region for potential resource extraction located underground;
- a mobile signal generator displaced by a seaborne vessel in order to sweep a region for potential resource extraction; said signals being reflected from said underground region for potential resource extraction and sensed by said sensors;
- means for transmitting signals to an analysis location;
- means for converting received signals into a volumetric model for identifying the configuration of said region for potential resource extraction;
- means for selecting a virtual drilling and/or extraction structure with predetermined properties from a bank of a plurality of virtual drilling and/or extraction structures; and
- means for calculating values representative of the operation of said selected drilling and/or extraction structure at a particular location for resource extraction.

This system is particularly advantageous because it allows an improvement in the probability of correctly locating the first drilling location. The drilling of so called dry holes is also minimised if not avoided altogether. It also allows improved accuracy for predicting the levels of extraction from a given site without having to physically drill. As a secondary advantage it also allows the prioritisation of the drilling operation for an entire field. This maximises the likely resource extractable from the field whilst reducing material costs and labour.

In a subsidiary aspect in accordance with the invention's first broad independent aspect, the system further comprises one or more volumetric displays for displaying a volumetric model representative of the operation of said selected drilling and/or extraction structure at a particular location for resource extraction. This configuration allows the team of drilling experts to visualise the effect of a chosen drilling angle on the exploration. It also allows multiple angles to be assessed by simply changing viewpoint. It also minimises the likelihood of obtaining dry holes. The system is also likely to accelerate the production profile. It also maximises the likely delivery of base reserves and therefore increases recovery. This would also allow engineers to obtain a birds' eye view of an entire operation.

In a subsidiary aspect in accordance with the invention's broadest independent aspect, the volumetric display is holographic with a portion being representative of a rig. This would allow real time analysis of data. It would achieve next to no carbon emissions. It would allow a method of exploration structure set up which would not optionally comprise the step of having to use an actual rig for drilling. Safety improvement if not complete safety when drilling operations are monitored from the relative comfort of a volumetric display which may be also called holographic theatre in the drilling operations' office.

In a further subsidiary aspect, means are provided to allow an operator to input operational conditions selected from the group comprising: temperature, seabed type, weather, marine conditions, salinity, seasonal conditions and wind direction. These systems allow the improved planning for the stages of drilling and mounting of the resource extraction structure.

It also allows operators to compare the relative overall requirements for extraction of a resource at disparate locations worldwide from a single assessment point.

In a further subsidiary aspect, two separate volumetric displays are employed: one of the displays being selected for the modelling of said drilling and/or said extraction structure whilst the second display models said region for potential resource extraction. This configuration is particularly advantageous because it allows the overall display to be compact as opposed to a single display covering both aspects. It also allows the taking into account of the relative scales of a resource extraction platform and a selected region for potential resource extraction.

In a further subsidiary aspect, said volumetric display is tower shaped and higher than it is wide. This configuration is particularly advantageous because it marks a complete departure from the prior art display units, which are primarily wider than they are high.

In a further subsidiary aspect, said volumetric display incorporates an array of light emitting voxels positioned within a three-dimensional space. This allows the system to be implemented for example every context of a board meeting without requiring special lighting conditions in a given assessment station.

In a second broad independent aspect, the invention provides a method for modelling resource extraction, comprising the steps of:

- laying below the upper surface of the seabed or sufficiently adjacent to the seabed an array of seismic cables with a plurality of spaced apart sensors located on said cables;
- displacing a vessel with a mobile signal generator in order to sweep a region for potential resource extraction; said signals being reflected from an underground region for potential resource extraction and sensed by said sensors;
- transmitting signals to an analysis location;
- converting received signals into a volumetric model;
- selecting a virtual drilling and/or extraction structure with predetermined properties from a bank of a plurality of virtual drilling and/or extraction structures; and
- calculating values representative of the operation of said selected drilling and/or extraction structure at a particular location for resource extraction.

This method marks a complete departure from the prior art teaching of immediate drilling in accordance with a three-dimensional map.

In a subsidiary aspect in accordance with the invention's second broadest independent aspect, the method comprises the step of displaying on a volumetric display a volumetric model representative of the operation of said selected drilling and/or extraction structure on a particular location for resource extraction.

This method is particularly advantageous because it allows the operator to select a drilling and/or extraction structure and assess its effect on a location for resource extraction. It also allows the drilling action to be observed from a plurality of angles.

In a further subsidiary aspect, the method comprises the step of inputting operational conditions selected from the group comprising: temperature, seabed type, weather, marine conditions, salinity, seasonal conditions and wind direction. This method is particularly advantageous because it allows the operator to for example adapt the selection of structures dependent upon these factors and to assess the feasibility overall of initiating actual drilling and/or resource extraction at a particular location.

In a further subsidiary aspect, the method comprises the step of calculating and displaying the rate of extraction for a particular location. This method also allows the operators to prioritise the actual drilling and/or resource extraction operation with both a long-term view and a short-term view.

Description of the Figures

Figure 1 shows a schematic view of the system in accordance with a first embodiment of the invention.

Figure 2 shows a volumetric display unit and a controller in accordance with a second embodiment of the invention.

Figure 3 shows a flow diagram of the steps followed in an embodiment of the invention.

Detail Description of the Figures

Figure 1 generally shows an overview of the system in the form of a volumetric segment generally referenced 1, where a layer of sea 2 is illustrated above a seabed 3 and a potential resource extraction layer 4. In seabed 2, a number of seismic cables such as cable 5 are placed. Such cables may be located underneath the upper surface 6 of the seabed in order to protect the cables from damage. The cables incorporate a plurality of regularly spaced sensors 7 which are adapted to receive signals reflected from an underground region 4. A seismic source is fired by vessel 8 as shown by arrows 9. The reflected signals are illustrated by arrows 10. A gas cloud, a gas and/or an oil pocket such as pocket 11 will tend to attenuate or modify in known ways the seismic pressure waves. Some pressure waves will be for example converted into shear waves. These variations in sensed signals provide the information necessary to map the region for potential resource extraction. The reflected seismic signals are picked up by individual sensors and are then recorded at an off-shore platform. The link between the cables and the platform may be established between a canister 12 located at least in part in the seabed for housing and/or protecting the electrical equipment necessary for driving the sensors and for relaying the information to a platform.

The data gathered at an off-shore platform is then transferred to an on-shore processing location through an optical cable which may itself be imbedded into the seabed.

In further embodiments, a hydrophone may be placed about the seabed to generate a signal in the form of sound waves, which return to a shooting vessel such as vessel 8 and are then relayed to appropriate processing means.

The elements of figure 1 can be converted into a volumetric display by for example employing a three-dimensional array of voxels, which may be light emitting. An example of a suitable arrays is detailed in US 5,801,666 which is enclosed by reference. Means may be provided to vary the colour of individual voxels to present the combination of a mapped underground region for potential resource extraction in combination with a drilling rig such as drilling rig 13 in figure 1 which is connected to an oil pocket 11 via a drilling line 14.

In order to illuminate individual voxels, a controller is provided in order to drive an optical switch which selectively sends beams of light to appropriate voxels in the array.

Figure 2 shows an array 15 with a plurality of voxels such as voxels 16. For simplicity, figure 2 only shows the first of the volumetric displays. The number of voxel selected is sufficient to clearly indicate the three-dimensional size of a given oil pocket and to show its interaction with a drilling rig. To this end, the volumetric display is preferably higher than it is wide. It is envisaged that the lower region referenced 17 will depict the potential resource extracting region whilst region 18 would depict the drilling rig and/or alternative resource extraction structure such as a conductor supported well. The system's controller provides means for inputting the three-dimensional resource data gathered through the seismic array. It also gathers the drilling structure, the resource extraction structure and the environmental data in order to modify the visible structure selected and to illustrate the achievable rate of extraction. Drilling engineers and/or experts and/or board members would be able to employ the controller to select particular drilling structures from known kind and to view the positioning of the drilling line relative to an oil line in order to view the drilling and/or resource extraction performance for various positions of the drilling line dependant upon the resource data and specific environmental data.

This would also allow the input of real reservoir characteristics to a drilling unit and to improve the full field development program based on this initial analysis.

This approach will have the particular benefits of reducing substantially the required drilling time and therefore the expense for the drilling since hotspots may be assessed by a reservoir engineer using this method without having to dive under water or send further equipment to drill. There would also be considerable health, safety and environmental benefits due to the reduction in drilling time. There would also be faster and more efficient drilling programs deployed which would resort in an acceleration of the field development. This approach will also allow an improved interface between the off-shore drilling team and the on-shore team to optimise drilling programs.

It will also allow a virtual drilling program to be evaluated in order to produce early indications of production capacity. It would also allow dry holes to be illuminated and for the resources to be focused on the most economically viable drilling approaches.

This would also have particular benefits for assessing depleted oil reserves where the conventional drilling program would not be economically viable.

The method is shown in overview in figure 3 where the following steps are envisaged:

- Laying seismic cables;
- Displacing signal generator vessels;
- Sensing reflected signals;
- Transmitting signals;
- Generating volumetric model;
- Selecting virtual drilling structures; and
- Generating time varying volumetric model dependent upon selected drilling structure.

CLAIMS

1. A resource extraction modelling system, comprising:

- an array of seismic cables;
- a plurality of spaced apart sensors located on said cables; said cables being located below the surface of the seabed or sufficiently adjacent to a seabed for receiving signals reflected from a region for potential resource extraction located underground;
- a mobile signal generator displaced by a seaborne vessel in order to sweep a region for potential resource extraction; said signals being reflected from said underground region for potential resource extraction and sensed by said sensors;
- means for transmitting signals to an analysis location;
- means for converting received signals into a volumetric model for identifying the configuration of said region for potential resource extraction;
- means for selecting a virtual drilling and/or extraction structure with predetermined properties from a bank of a plurality of virtual drilling and/or extraction structures; and
- means for calculating values representative of the operation of said selected drilling and/or extraction structure at a particular location for resource extraction.

2. A system according to claim 1, further comprising one or more volumetric displays for displaying a volumetric model representative of the operation of said selected drilling and/or extraction structure at a particular location for resource extraction.

3. A system according to either of the preceding claims, wherein means are provided to allow an operator to input operational conditions selected from the group comprising: temperature, seabed type, weather, marine conditions, salinity, season and wind direction.

4. A system according to either of the preceding claims, wherein two separate volumetric displays are employed: one of the displays being selected for the modelling of said drilling and/or said extraction structure whilst the second display models said region for potential resource extraction.

5. A system according to any of the preceding claims, wherein said volumetric display is tower shaped and higher than it is wide.

6. A system according to any of the preceding claims, wherein said volumetric display incorporates an array of light emitting voxels positioned within a three-dimensional space.

7. A method for modelling resource extraction, comprising the steps of:

- laying below the surface of the seabed or sufficiently adjacent to the seabed an array of seismic cables with a plurality of spaced apart sensors located on said cables;
- displacing a vessel with a mobile signal generator in order to sweep a region for potential resource extraction; said signals being reflected from an underground region for potential resource extraction and sensed by said sensors;
- transmitting signals to an analysis location;
- converting received signals into a volumetric model;
- selecting a virtual drilling and/or extraction structure with predetermined properties from a bank of a plurality of virtual drilling and/or extraction structures; and
- calculating values representative of the operation of said selected drilling and/or extraction structure at a particular location for resource extraction.

8. A method according to claim 7, comprising the step of displaying on a volumetric display a volumetric model representative of the operation of said selected drilling and/or extraction structure on a particular location for resource extraction.

9. A method according to either of the preceding claims, comprising the step of inputting operational conditions selected from the group comprising: temperature, seabed type, weather, marine conditions, salinity, season and wind direction.

10. A method according to any of claims 7 to 9, comprising the step of calculating and displaying the rate of extraction for a particular location.

11. A resource extraction modelling system and/or method for modelling resource extraction substantially as hereinbefore described and/or illustrated with reference to any appropriate combination of the accompanying text and/or figures.

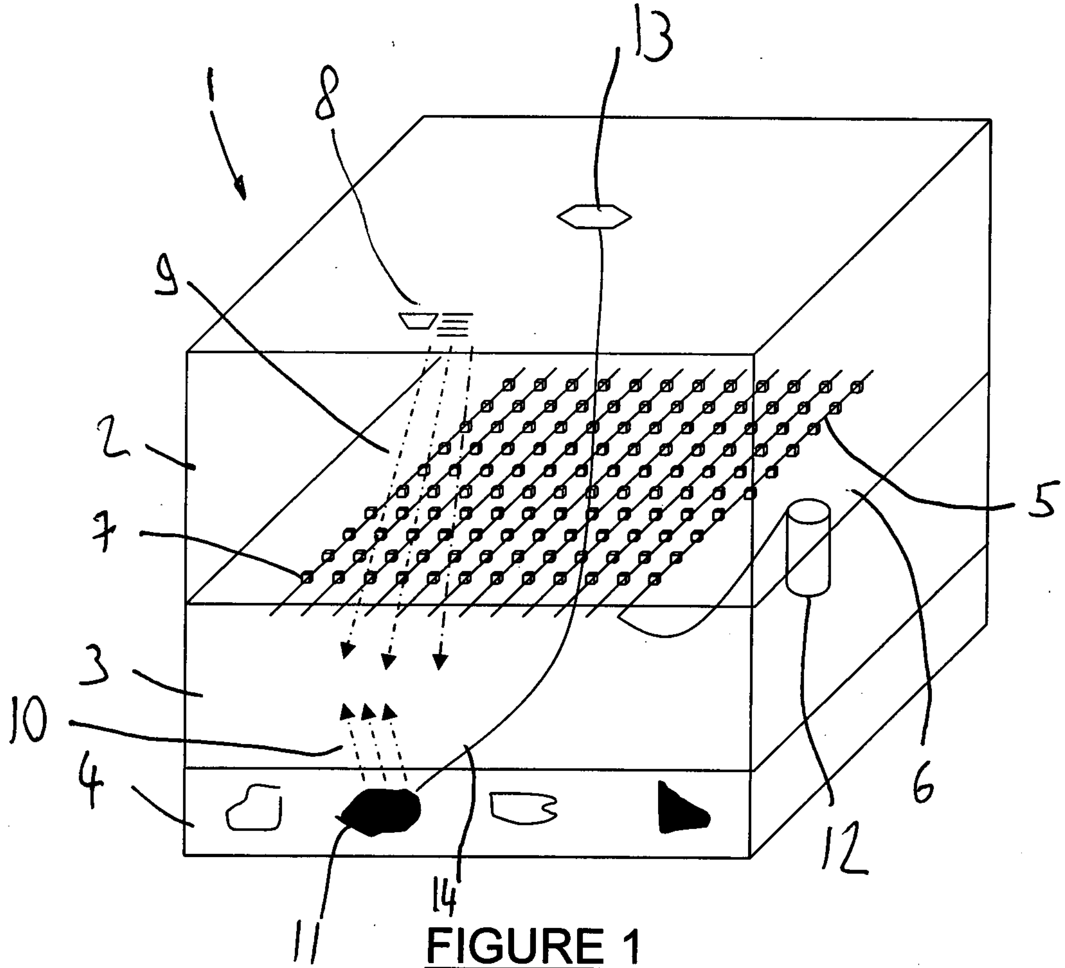

FIGURE 1

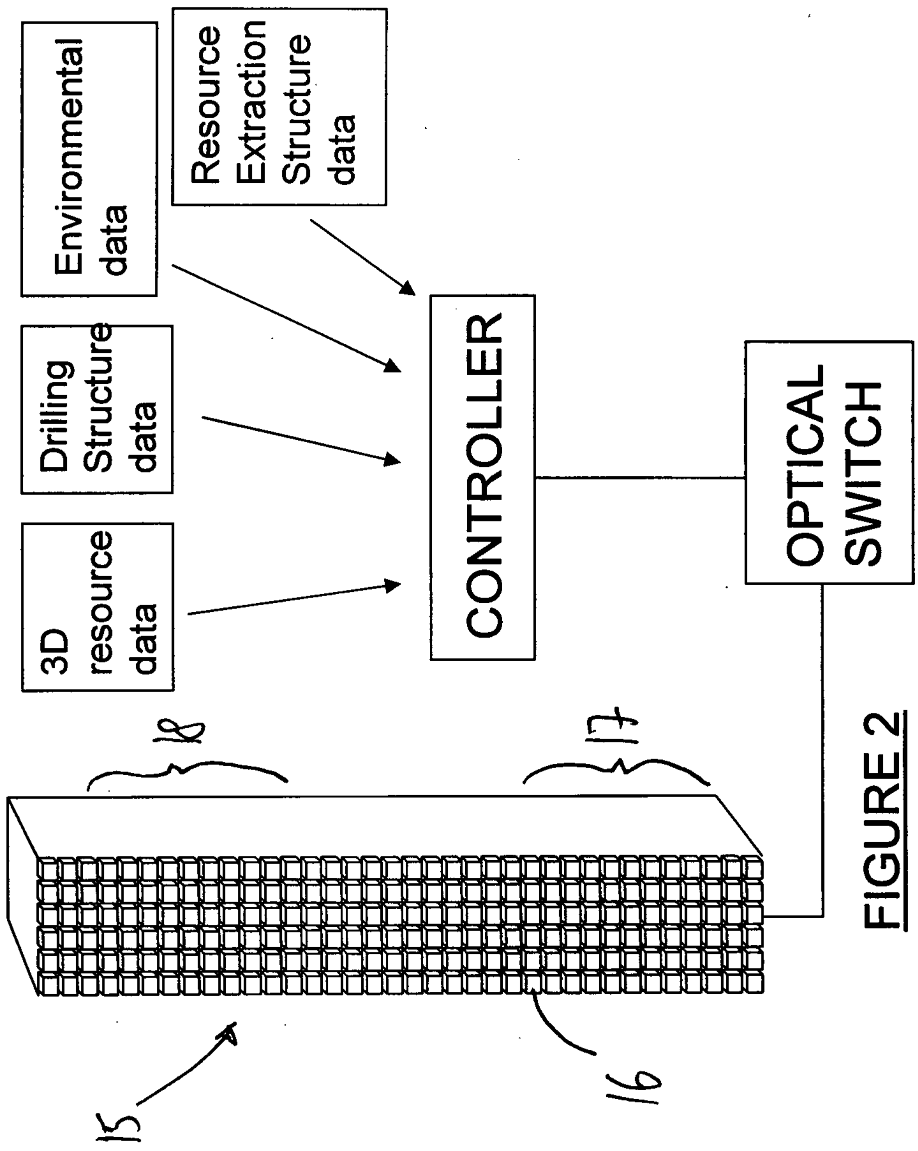
Environmental data
Resource Extraction Structure data
Drilling Structure data
3D resource data
CONTROLLER
OPTICAL SWITCH
18
17
15
16

FIGURE 2

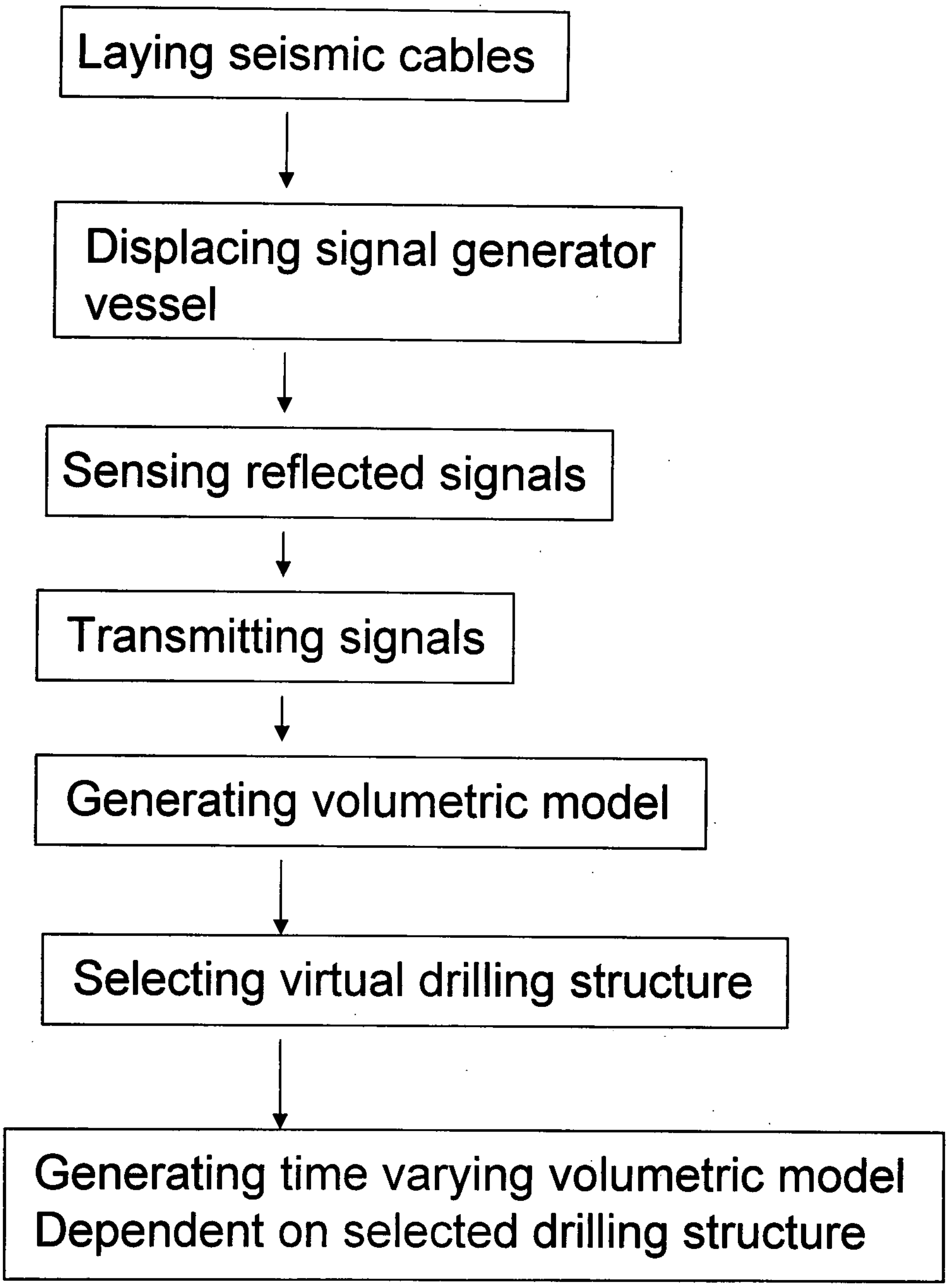
Laying seismic cables
Displacing signal generator vessel
Sensing reflected signals
Transmitting signals
Generating volumetric model
Selecting virtual drilling structure
Generating time varying volumetric model Dependent on selected drilling structure

Figure 3