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(54) **Title**: IMPROVEMENTS IN OR RELATING TO WIRELESS DATA RECOVERY

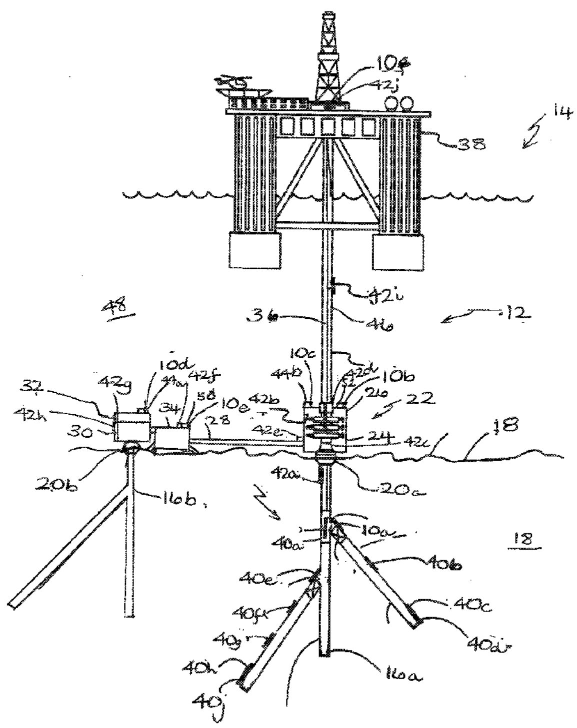

Figure 1

(57) **Abstract**: A black box recorder system and associated method for use in a well, such as an oil well, the system comprising a black box recorder including one or more inputs for receiving data from a measurement device in the well, a data storage unit, and a transmitter for wireless data transmission; and a receiver for the wireless data transmission, the receiver being located on a retrieval unit. The recorder records data received and may include time indicators in the recorded data. When the data is to be recovered a retrieval unit is brought into range of the transmitter and the data required is transmitted to the retrieval unit. The transmitter and receiver may be operable to transmit using electromagnetic transmission techniques.

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IMPROVEMENTS IN OR RELATING TO WIRELESS DATA RECOVERY

The present invention relates to monitoring equipment used in oil and gas exploration and production and in particular, though not exclusively, to a black box recorder system for data collection to aid in the determination of the causes of an accident or critical fault at an offshore well.

On 20 April 2010, the Deepwater Horizon semi-submersible Mobile Offshore Drilling Unit (MODU), whilst drilling in the Macondo Prospect oil field about 40 miles (60 km) southeast of the Louisiana coast, suffered an explosion causing the MODU to burn and sink. There were eleven fatalities and the consequential offshore oil spill was a major environmental emergency. Following the disaster, much work has been done in trying to determine the cause of the accident. Historical information is also being considered to see if there were any indicators to predict the accident which could be used in the future to prevent such a disaster occurring again.

Reports show that while the wellhead on the sea floor had been fitted with a blow-out preventer (BOP) including a dead man's switch designed to automatically cut the pipe and seal the well if communication from the platform is lost, it is not known whether the switch was activated. This is only one event where it is clear that the information no longer exists which could tell us what happened at a crucial moment in the accident. Due to the loss of communication from the wellhead to the platform and the resulting damage to equipment, it is impossible to determine precisely the sequence of events which led to the disaster both at the time of the explosion and in the period leading up to the accident.

In the aviation industry, black box flight recorders are now mandatory. Traditional black box flight recorders were an audio recording device which recorded the conversation of the pilots. More modern black box flight recorders are hardwired to systems transducers, sensors and other monitoring equipment with the time stamped data being stored in a memory within the box. The black box is impact resistant and designed to withstand a crash so that, when required, it can be retrieved and the stored record of the flight can be replayed to provide critical information to aid in the determination of the causes of the accident or malfunction.

Though black box recorders are well known in aviation, they are not considered appropriate for use in well bores for the oil and gas industry. This is because in the event of a plane crash, accident investigators usually have easy access to the site to locate the black box flight recorder. The black box flight recorders are also deliberately located in the tail of the aircraft which is the least likely place to suffer damage in a crash and also the most likely to effectively scatter the contents of the aircraft in the event of an explosion, being distant to the fuel tanks which are typically in the wings. These opportunities do not exist at a well.

A black box recorder cannot be mounted in the casing or lining of a well bore as it would not be retrievable in the event of an accident or malfunction downhole. Locating a black box recorder on a tool string may make it retrievable, but only if the tool string sticks below the position of the black box recorder and the BOP is not operated to seal the well. Such a black box recorder would also be limited to only collecting data from sensors or gauges mounted on the tool string so that data is recorded only for the time and locations the tool string is in the well bore. A black box recorder at a wellhead would also be difficult to retrieve. An ROV would typically be guided to the wellhead and would be used to disconnect the black box recorder from the subsea structure. This is a difficult enough procedure in calm shallow waters, but in circumstances like the Macondo disaster, ROVs have limited control in the deep water; if the structure is damaged, the black box recorder may be inaccessible; ROVs operate using underwater cameras which cannot see through oil, so that retrieval is impossible in an oil spill or where the water is turbulent such as in a gas leak at the wellhead.

In this specification, the term ‘in a well’ encompasses all areas of a well where well fluids can be present including, in a wellbore, at a wellhead, over subsea conduits e.g. risers, pipelines, at subsea distribution facilities and at the connections to a vessel e.g. platform, rig or FPSO.

It is an object of the present invention to provide a black box recorder, system and method of data retrieval from a black box recorder in a well.

According to a first aspect of the present invention there is provided a black box recorder system for use in a well, the system comprising:

a black box recorder including one or more inputs for receiving data from a measurement device in the well, a data storage unit, and a transmitter for wireless data transmission;

and a receiver for the wireless data transmission, the receiver being located on a retrieval unit and the retrieval unit being brought into range of the transmitter when data needs to be recovered from the black box recorder.

In this way, the black box recorder can store time stamped data from any number of devices as would occur with a black box flight recorder. However, the black box of the present invention does not have to be retrievable. By bringing a receiver within range of the black box's transmitter, the data can be wirelessly transferred to a retrieval unit.

Preferably the transmitter and the receiver have an electrically insulated magnetic coupled antenna. Alternatively, the transmitter and the receiver have an electric field coupled antenna. The antenna may be a wire loop, coil or similar arrangement. Such antenna create both magnetic and electromagnetic fields. The magnetic or magneto-inductive field is generally considered to comprise two components of different magnitude that, along with other factors, attenuate with distance (r), at rates proportional to $1/r^2$ and $1/r^3$ respectively. Together they are often termed the near field components. The electromagnetic field has a still different magnitude and, along with other factors, attenuates with distance at a rate proportional to 1/r. It is often termed the far field or propagating component. In this way the data is transmitted as an electromagnetic or magneto-inductive signal.

Preferably the black box has an impact resistant housing. In this way, the stored data will be protected in the event of an accident. Preferably also, the transmitter is housed within the black box. In this way, the transmitter is also protected in the event of an accident or malfunction.

Preferably, the transmitter and the receiver are transceivers. In this way, bi-directional communications can occur between the black box and the retrieval unit.

In this way each can identify itself to the other to confirm they are in range. Additionally, the retrieval unit can retrieve only selected data if required.

Preferably the system further comprises one or more measurement devices. Preferably, the one or more measurement devices are a mix selected from gauges, sensors, valves, sampling devices, a device used in intelligent or smart well completion, temperature sensors, pressure sensors, flow-control devices, flow rate measurement devices, oil/water/gas ratio measurement devices, scale detectors, actuators, locks, release mechanisms, equipment sensors (e.g., vibration sensors), sand detection sensors, water detection sensors, data recorders, viscosity sensors, density sensors, bubble point sensors, composition sensors, resistivity array devices and sensors, acoustic devices and sensors, other telemetry devices, near infrared sensors, gamma ray detectors, H_2S detectors, CO_2 detectors, downhole memory units, downhole controllers, and locators.

The measurement devices may have outputs which are hard wired to the input of the black box recorder. Preferably each measurement device has a transmitter and the black box recorder has a receiver. In this way data from each measurement device can be wirelessly transmitted to the black box recorder. The receiver may be part of the transceiver in the black box recorder. The transmitter may be a transceiver to allow bi-directional signals between the measurement device and the black box recorder. Advantageously, the measurement devices are both hard wired and include a transmitter. This arrangement allows for data transmission wirelessly as a back-up if the hard wiring is interrupted, as may occur in an incident. The wireless connection means that measurements can be made during an accident/malfunction providing valuable data to assess outcomes.

Preferably, the black box recorder has an internal power supply. In this way, power can be used by the transmitter to transmit data to the retrieval unit. Preferably also, the measurement devices have their own power supplies. In this way, the devices remain operational and data can still be transmitted following an accident or malfunction.

Preferably, the retrieval unit is a mobile underwater vehicle. More preferably, the retrieval unit is an autonomous underwater vehicle (AUV). More preferably, the mobile underwater vehicle is a remotely operated vehicle (ROV). Such vehicles are already used in a subsea environment and can be guided to a wellhead or other subsea location of a well.

In another embodiment, the retrieval unit is a tool locatable on a tool string. In this way the retrieval unit can be moved through a well bore to be located near the black box recorder.

Preferably, there is a plurality of black box recorders arranged around the well. More preferably, a black box recorder may be located beside each measurement device. As the retrieval unit can be positioned to be in range of a number of black box recorders at the same time, downloading the data is simplified. Additionally, a black box recorder at each measurement device ensures the data is transmitted to the black box recorder.

According to a second aspect of the present invention there is provided a black box recorder for locating in a well, the black box recorder comprising a housing including one or more inputs for receiving data from a measurement device in the well, a data storage unit, and a transmitter for wireless data transmission.

In this way, the black box recorder can store time stamped data from any number of devices as would occur with a black box flight recorder while at the same time being able to transmit the data wirelessly if required.

Preferably the transmitter has an electrically insulated magnetic coupled antenna. Alternatively, the transmitter has an electric field coupled antenna. The antenna may be a wire loop, coil or similar arrangement. Such antenna create both magnetic and electromagnetic fields. The magnetic or magneto-inductive field is generally considered to comprise two components of different magnitude that, along with other factors, attenuate with distance (r), at rates proportional to $1/r^2$ and $1/r^3$ respectively. Together they are often termed the near field components. The electromagnetic field has a still different magnitude and, along with other factors, attenuates with distance at a rate proportional to 1/r. It is often termed the far field or propagating component. In this way the data is transmitted as an electromagnetic or magneto-inductive signal.

Preferably the housing is an impact resistant housing. In this way, the stored data will be protected in the event of an accident. Preferably also, the transmitter is housed within the black box. In this way, the transmitter is also protected in the event of an accident or malfunction.

Preferably, the transmitter is a transceiver. In this way, bi-directional communications can occur between the black box and a retrieval unit.

Preferably, the black box recorder has an internal power supply. In this way, power can be used by the transmitter to transmit data to a retrieval unit.

According to a third aspect of the present invention there is provided a method for data recordal and retrieval via a black box recorder in a well, the method comprising the steps:

(a) locating a black box recorder, according to the second aspect, in a well;
(b) locating one or more measurement devices in a well;
(c) transmitting data from the one or more measurement devices to the black box recorder;
(d) storing the transmitted data with time indicators on the data storage unit;
(e) guiding a retrieval unit to within range of the transmitter of the black box recorder; and
(f) downloading transmitted data from the black box recorder to the retrieval unit by wireless transmission.

In this way, the black box recorder does not have to be retrieved to surface in order to download the transmitted data. Additionally, no physical contact is required between the black box recorder and the retrieval unit for data download.

In an embodiment, the data transmitted from the measurement devices to the black box recorder is by wireless transmission.

Preferably, the method includes the step of wirelessly transmitting the data as an electromagnetic and/or magneto-inductive signal. Signals based on electrical and electromagnetic fields are rapidly attenuated in water due to its partially electrically conductive nature. Propagating radio or electromagnetic waves are a result of an interaction between the electric and magnetic fields. The high conductivity of seawater attenuates the electric field. The conductivity of fluids in the wellbore also attenuates the electric field. Water has a magnetic permeability close to that of free space so that a purely magnetic field is relatively unaffected by this medium. However, for propagating electromagnetic waves the energy is continually cycling between magnetic and electric field and this results in attenuation of propagating waves due to conduction losses. The seawater provides attenuation losses in a workable bandwidth which still provide for data transmission over practical distances.

Advantageously, the method may include the step of switching transmission of data from the measurement devices to the black box recorder, from a hardwired connection to a wireless connection. In this way, if a malfunction occurs on any of the hardwired connections, data transmission to the black box recorder can still be maintained.

Preferably, the method includes the step of guiding an autonomous underwater vehicle (AUV) to within range of the black box recorder, the AUV including a receiver for wirelessly downloading the data.

Alternatively, the method includes the step of running the retrieval unit on a tool string into a well bore to position the retrieval unit within range of the black box recorder. The method may include the step of drilling into the well bore, to clear a path for the tool string and retriever unit. In this way, if the wellbore is sealed by the BOP or collapses during an accident, once stabilized the well bore can be drilled through to position a retrieval unit within range of the black box recorder. The electromagnetic and/or magneto-inductive signal will transmit through solids such as rock. The tool string may be a tubing string, slickline or wireline.

Advantageously, the method may include the step of guiding the retrieval unit into close proximity to the black box recorder and transferring power by magnetic induction from the retrieval unit to the black box recorder. This may be required where the black box recorder has exhausted its power supply and/or the power supply has become damaged and inoperable due to an accident or a malfunction.

Preferably the method includes the step of downloading transmitted data from a plurality of black box recorders in the well to the retrieval unit by wireless transmission. In this way, black box recorders can be located around the well and only a single trip by the retrieval unit is required to download the data.

Preferably, the method includes the step of compressing the data prior to wireless transmission. In this way the occupied transmission bandwidth can be reduced. This allows use of a lower carrier frequency which leads to lower attenuation. This in turn allows data transfer through fluids over greater transmission distances so that the retrieval unit does not require to be close to the black box recorder to collect data.

Preferably, the wireless data transmission is bi-directional. In this way, command and control signals can be transferred to a microprocessor in the black box recorder so that selected data can be downloaded from the black box recorder if required.

An embodiment of the present invention will now be described, by way of example only, with reference to the accompanying drawings of which:

Figure 1 is a schematic illustration of a well including a black box recorder according to an embodiment of the present invention;

Figure 2 is a block diagram of a transceiver for use in a black box recorder system of the present invention;

Figure 3 is a block diagram of an antenna for use in the transmitter or receiver of the transceiver of Figure 2;

Figure 4 is a schematic illustration of the well of Figure 1 following an explosion, including a black box recorder system according to an embodiment of the present invention; and

Figure 5 is a schematic illustration of the wellbore of Figure 1 following an explosion, including a black box recorder system according to an embodiment of the present invention.

Reference is initially made to Figure 1 of the drawings which illustrates a black box recorder, generally indicated by reference numeral 10, in a well 12, according to an embodiment of the present invention. Well 12 can be considered as part of a hydrocarbon production facility 14.

Facility 14 comprises wellbores 16a,b drilled into a formation 18. Each wellbore 16 reaches the seabed 18 at a wellhead 20a,b. The subsea installation 22 comprises equipment such as a BOP 24, lower stack 26, pipeline 28, compressor 30, manifold 32 and pump 34. A riser 36 takes the produced fluids to a rig 38. A variety of sensors 40a-j,42a-j which are measurement devices are located across the well 12. In such a production facility the measurement devices may be selected from gauges, sensors, valves, sampling devices, a device used in intelligent or smart well completion, temperature sensors, pressure sensors, flow-control devices, flow rate measurement devices, oil/water/gas ratio measurement devices, scale detectors, actuators, locks, release mechanisms, equipment sensors (e.g., vibration sensors), sand detection sensors, water detection sensors, data recorders, viscosity sensors, density sensors, bubble point sensors, composition sensors, resistivity array devices and sensors, acoustic devices and sensors, other telemetry devices, near infrared sensors, gamma ray detectors, H_2S detectors, CO_2 detectors, downhole memory units, downhole controllers, and locators. Additionally, control modules 44a,b are positioned over the facility 14 to provide operational capability. As is typical the sensors 40,42 and the control modules 44 are hardwired to the rig 38 via an umbilical 46 tethered to the riser 36. In this way, power transfer, control signals and data collection occur via the umbilical between the rig 38 and equipment at the first wellhead 20a. The sensors 42f-h and control module 44a are located on equipment at the second wellhead 20b which is remote from the umbilical 80. They are separated by a pipeline 28, which is not to scale in the Figure. An ROV (not shown) is required to travel through the sea 48, and the power transfer, control signals and data collection is achieved by wet-mate connection between the ROV and the sensors 42f-h and control module 44a.

In this embodiment, each sensor 40,42 and control module 44 is hardwired to a neighbouring black box recorder 10a-f. In this way all data generated at the sensors 40,42 is recorded by a black box recorder 10 and time stamped. Additionally all control signals to and from the control modules 44 are recorded by the black box recorder. It is noted that the black box recorders 10d,e are located at the control modules 44a,b to ensure a close link is provided without the requirement for lengths of exposed cables between the two. Each black box recorder has a memory storage facility which stores the recorded data. This may be a flash drive as is known in the art capable of storing gigabytes of data.

Each sensor 40,42 and control module 44 is also equipped with a transceiver 50 respectively. For clarity only one transceiver is marked on the drawing at sensor 42f. A further transceiver 52 is located in each black box recorder 10.

Reference is now made to Figure 2 of the drawings which illustrates parts of each transceiver 50,52. In transceiver 50, the sensor interface 56 receives data from the devices 40,42,44 which is forwarded to data processor 58. Data is then passed to signal processor 60 which generates a modulated signal which is modulated onto a carrier signal by modulator 62. Transmit amplifier 64 then generates the desired signal amplitude required by transmit transducer 66. In the transceivers 50,52 there is a control interface 68 which sends command signals to the data processor 58 which are transmitted by the above described path. These command signals can be used to identify one to another and synchronise the data between the device transceivers 50 and black box recorder transceivers 52.

The transceivers 50,52 also have a receive transducer 70 which receives a modulated signal which is amplified by receive amplifier 72. De-modulator 74 mixes the received signal to base band and detects symbol transitions. The signal is then passed to signal processor 76 which processes the received signal to extract data.

Data is then passed to data processor 58 which in turn forwards the data to control interface 68. For each transceiver 52 there is also a memory 78 which stores data. The memory 78 is used to store data from all the neighbouring sensors 40,42 and control modules 44.

Figure 3 shows an example of an antenna that can be used in the transmitter and receiver of Figure 2. This has a high permeability ferrite core 80. Wound round the core are multiple loops 82 of an insulated wire. The number of turns of the wire and length to diameter ratio of the core 80 can be selected depending on the application. However, for operation at 125 kHz, one thousand turns and a 10:1 length to diameter ratio is suitable. The antenna is connected to the relevant transmitter/receiver assembly parts described in Figure 2 and is included in a sealed housing 84. Within the housing the antenna may be surrounded by air or some other suitable insulator 86, for example, low conductivity medium such as distilled water that is impedance matched to the propagating medium 48.

During operation of the hydrocarbon production facility 14, fluids are produced through the well 12, while all control signals and sensor data is being recorded on a black box recorder 10, either through the hardwiring and/or via wireless transmission between the transceivers 50,52 as described above. While the well 12 could use one means of communication the use of both provides a back-up in the event that any hardwiring malfunctions or is damaged. Additionally, should the umbilical 46 fail, data can still be recorded by the black box recorders 10 and any emergency procedures signaled from the control modules 44 will also be recorded at the black box recorders 10. During normal operation of the facility, the black box recorders 10 do not interfere with any of the standard operating procedures such as shut-in or well intervention.

Reference is now made to Figure 4 of the drawings which illustrates a possible scenario of the hydrocarbon facility 14 of Figure 1, following an accident. In this case, the rig 38 has exploded and left debris 90, 92 which has either sunk to the seabed 18 or remains floating on the surface 94. At the subsea installation 22 the BOP 24, lower stack 26 and pipeline 28 have all suffered major damage. The remotely located compressor 30, manifold 32 and pump 34 have survived and are still operational. The riser 36 is entirely destroyed and parts may be left as debris 92 on the seabed 18. The wellbore 16b remains undamaged while the wellbore 16a may be damaged depending on the ability of the automatic shut-in emergency procedures to operate at the time of the explosion.

During the incident, the sensors 42a-e,j and control module 44b will have continued to send data wirelessly to the black box recorders 10b,c,f until such time as they were destroyed or the distance between them and the black box recorders 10b,c,f was out of range for the transceivers 50,52. Sensor data inside the wellbore 16a will have continuously been collected at the black box recorder 10a without change and will continue through and after the incident. Sensors 42f-h will have continued monitoring throughout the incident and onwards sending data to black box recorders 10d,e. The control module 44a, will have gone into an emergency shut-down procedure when the pipe 28 ruptured. This procedure will have been recorded in the black box recorder 10e together with changes in the sensed measurements at this part of the facility.

As part of the incident investigations, the information stored in the black box recorders 10 will give critical information to aid in the determination of the causes of the accident and in to the effectiveness of any emergency procedures put in place. It is clear that the black box recorders 10d,e are accessible and could be retrieved to surface while the remaining black box recorders are not accessible and for those located at explosion sites, their location will not be known.

In the present invention, an ROV 96 equipped with a transceiver 98 as described hereinbefore with reference to Figures 2 and 3, is guided over the wreckage of the subsea facility. When the transceiver 98 is within range of the transceiver 52 of any black box recorder 10, the transceivers will identify themselves to each other and data can be downloaded to the ROV 96 as described with reference to Figures 2 and 3. As transmission is wireless using electro-magnetic and magneto-inductive signals, the ROV 96 does not have to mate with the black box recorder 10, indeed black box recorders which are buried 10b,c will still be able to receive and transmit signals. Additionally, if the accident has caused an oil spill or a gas leak, transmission will be unaffected as the electro-magnetic and magneto-inductive signals can pass through

the gas/oil/seawater interfaces and media. This makes them advantageous over other signalling systems such as acoustics and optics.
Where a black box recorder 10f is accessible to the ROV 96, the transceivers 52,98 can be brought close together. In this position, the antenna can also be used to magnetically couple energy between the transceivers 52,98. Referring again to Figure 3, the housing acts as a magnetic flux guide and the multiple loops 82 with the ferrite core 80 provide a transformer when the pair of transceivers are brought together. In order for successful energy transfer the two transceivers must be arranged close together, there being an acceptable gap of only 1-2cm. Thus the range for power transfer is much smaller than the range for data communication. Coupling efficiency reduces as frequency increases because of leakage inductance effects. Eddy current losses increase with frequency so also act to reduce the bandwidth available for data transmission. Data and power transmission can be separated in frequency to allow simultaneous operation of the two functions. Transfer efficiency is more critical for power transfer than for data communication applications so a higher frequency will usually be assigned to the data communication signals. A separate transmitter coil arrangement can be provided solely for power transfer in both the ROV 96 and the black box recorders 10. This capability to transfer power to the black box recorder 10 may be required where a black box recorder is damaged or malfunctions in an incident such that it's internal power supply fails to operate.

Once the black box recorders 10b-f have had their data downloaded to the ROV 96, the ROV 96 can return to the surface and all the data can be analyzed to provide both historical data which may indicate why the incident occurred; data recorded during the incident to indicate what occurred; and data recorded following the incident to indicate the effect of the incident and how effective emergency procedures have been.

Now considering the black box recorder 10a located in the wellbore 16a. During the explosion, the BOP 24 should have sealed the wellbore 16a. Data recorded by the black box recorders 10b,c will provide details of what has occurred at the BOP 24 and the sensor 42a data will indicate if there are any problems at the wellhead 20a.

If the area at the wellhead 20a is unstable, it may be necessary to cement the wellbore 16a, to stabilize the wellbore 16a and prevent collapse.

Reference is now made to Figure 5 of the drawings which indicates the wellbore 16a where the bore 100 has been blocked. This blockage may have resulted by cementing or it could have occurred by the bore 100 collapsing as the result of an accident. In this embodiment a drill string 102 is run into the wellbore 16a, by drilling into the location using a drill bit 104 at the base of the string 102. A retrieval unit 106, including a transceiver 110, is located on the string 102 behind the motor 108. Transceiver 110 is as described with reference to Figures 2 and 3.

As the bore 100 is drilled, the retrieval unit 106 is guided towards the black box recorder 10a. When the transceiver 110 is within range of the transceiver 52 in the black box recorder 10a, the transceivers 52,110 will identify themselves to each other and data can be downloaded wirelessly from the black box recorder 10a. As the electro-magnetic and magneto-inductive signals can pass through solids such as cement and rock, the transceivers do not need to be in physical contact to download the data. The drill string 102 can be pulled from the wellbore 16a and the retrieval unit 106 returned to surface for analysis of the data.

It will be appreciated that the data could be retrieved by having a drill string without the retrieval unit first drilling a borehole close to the black box recorder. The drill string could be POOH and another tool string, on which the retrieval unit is located, could be run in the hole to retrieve the data.

The principle advantage of the present invention is that it provides a black box recorder with a system and method for use in a well.

A further advantage of the present invention is that it provides a black box recorder system for a well in which the black box recorder does not require to be physically retrievable in the event of an incident.

A further advantage of at least one embodiment of the present invention is that it provides a black box recorder system for a well in which data can still be recorded by the black box recorder during an incident in which cables malfunction.

It will be appreciated by those skilled in the art that various modifications may be made to the invention herein described without departing from the scope thereof. For example, manned submarines or divers could be used to guide a retrieval unit to retrieve the data. While a rig is illustrated, the well may include a platform, semi-submersible, FPSO or may simply have a pipeline to surface.

Claims

1. A black box recorder system for use in a well, the system comprising:

   a black box recorder including one or more inputs for receiving data from a measurement device in the well, a data storage unit, and a transmitter for wireless data transmission;

   and a receiver for the wireless data transmission, the receiver being located on a retrieval unit and the retrieval unit being brought into range of the transmitter when data needs to be recovered from the black box recorder.

2. A black box recorder system as claimed in claim 1 wherein the transmitter and the receiver have an electrically insulated magnetic coupled antenna.

3. A black box recorder system as claimed in claim 1 wherein the transmitter and the receiver have an electric field coupled antenna.

4. A black box recorder system as claimed in any preceding claim wherein the black box has an impact resistant housing.

5. A black box recorder system as claimed in any preceding claim wherein the transmitter is housed within the black box.

6. A black box recorder system as claimed in any preceding claim wherein the transmitter and the receiver are transceivers.

7. A black box recorder system as claimed in any preceding claim wherein the system further comprises one or more measurement devices.

8. A black box recorder system as claimed in claim 7 wherein the measurement devices has outputs which are hard wired to the input of the black box recorder.

9. A black box recorder system as claimed in any of claims 7 or 8 wherein each measurement device has a transmitter and the black box recorder has a receiver.

10. A black box recorder system as claimed in claim 9 wherein the receiver is part of the transceiver in the black box recorder.

11. A black box recorder system as claimed in any of claims 7 to 10 wherein the transmitter is a transceiver operable to allow bi-directional signals between the measurement device and the black box recorder.

12. A black box recorder system as claimed in any preceding claim wherein the measurement devices are both hard wired and include a transmitter.

13. A black box recorder system as claimed in any preceding claim wherein there are a there is a plurality of black box recorders arranged around the well.

14. A black box recorder for locating in a well, the black box recorder comprising a housing including one or more inputs for receiving data from a measurement device in the well, a data storage unit, and a transmitter for wireless data transmission.

15. A black box recorder as claimed in claim 14, wherein the transmitter has an electrically insulated magnetic coupled antenna.

16. A black box recorder as claimed in claim 14, wherein, the transmitter has an electric field coupled antenna.

17. A black box recorder as claimed in claim 14, wherein the housing is an impact resistant housing.

18. A black box recorder as claimed in claim 14, wherein also, the transmitter is housed within the black box.

19. A method for data recordal and retrieval via a black box recorder in a well, the method comprising the steps:

(a) locating a black box recorder as claimed in any preceding claim in a well;

(b) locating one or more measurement devices in a well;

(c) transmitting data from the one or more measurement devices to the black box recorder;

(d) storing the transmitted data with time indicators on the data storage unit;

(e) guiding a retrieval unit to within range of the transmitter of the black box recorder; and

(f) downloading transmitted data from the black box recorder to the retrieval unit by wireless transmission.

20. A method for data recordal and retrieval via a black box recorder as claimed in claim 19 wherein the data transmitted from the measurement devices to the black box recorder is by wireless transmission.

21. A method for data recordal and retrieval via a black box recorder as claimed in claim 19 wherein the method includes the step of wirelessly transmitting the data as an electromagnetic and/or magneto-inductive signal.

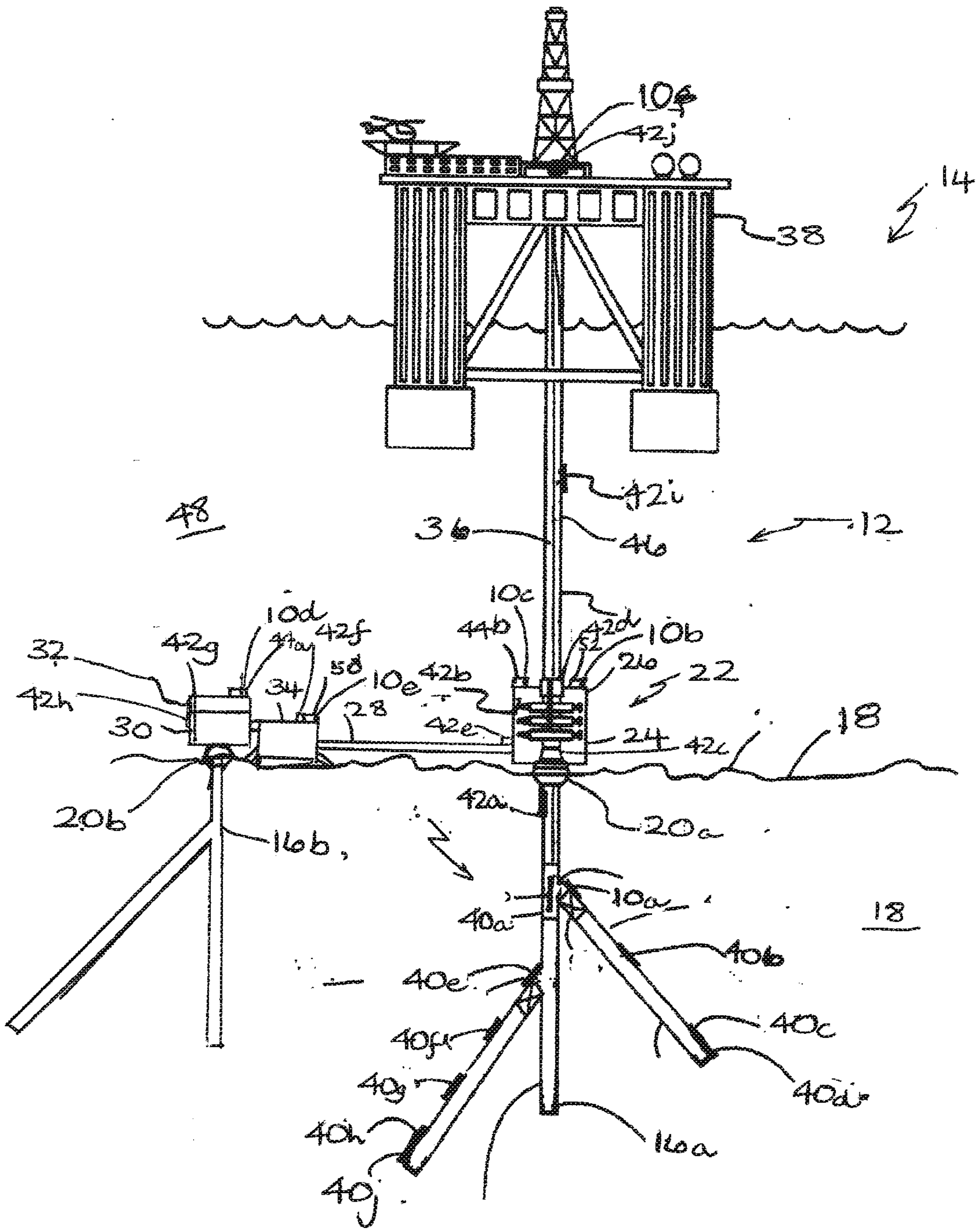
10f
42j
14
38
42i
48
36
46
12
10c
44b
42d
10b
52
26
22
10d
44a
42f
32
42g
58
10e
42b
34
42h
30
28
42e
24
42c
18
20b
42a
20a
16b
10a
40a
18
40b
40e
40c
40f
40g
40d
40h
16a
40j

Figure 1

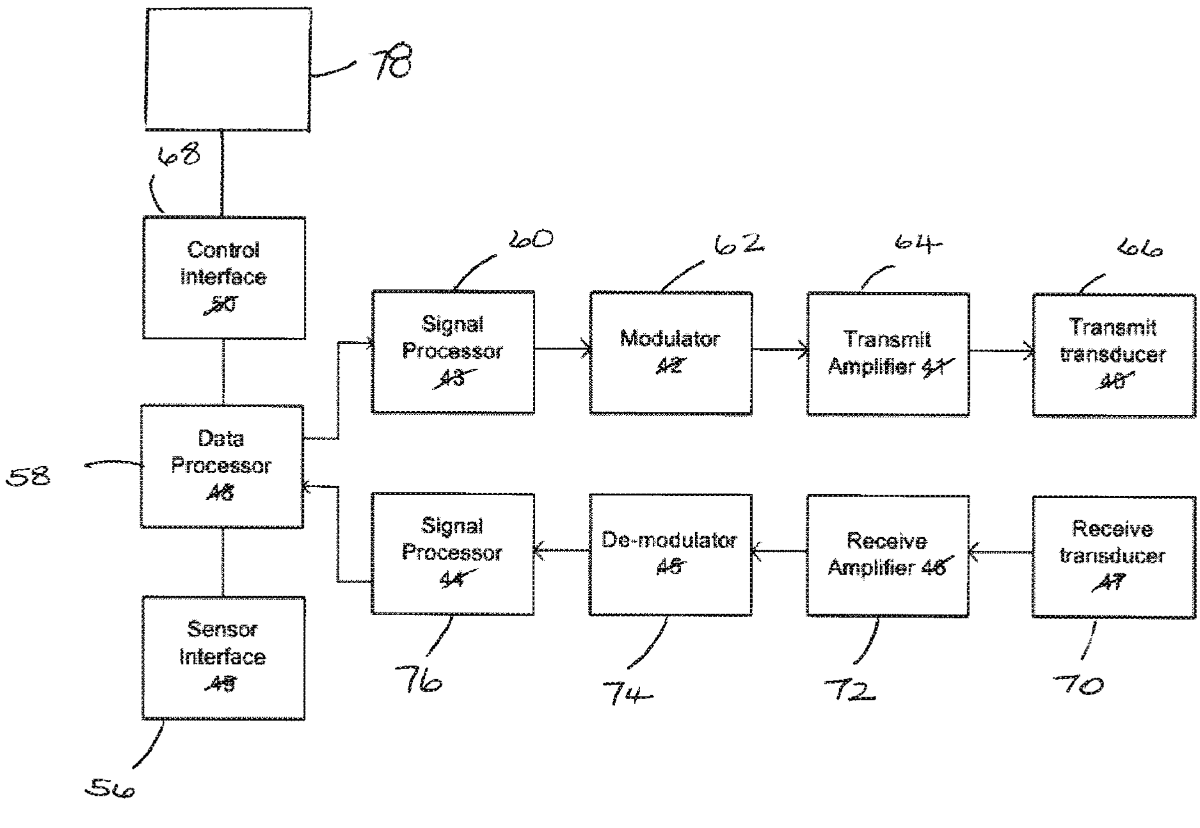
78
68
Control interface 50
Data Processor 46
Sensor Interface 48
58
56
60
Signal Processor 43
62
Modulator 42
64
Transmit Amplifier 41
66
Transmit transducer 40
Signal Processor 44
De-modulator 45
Receive Amplifier 46
Receive transducer 47
76
74
72
70

Figure 2

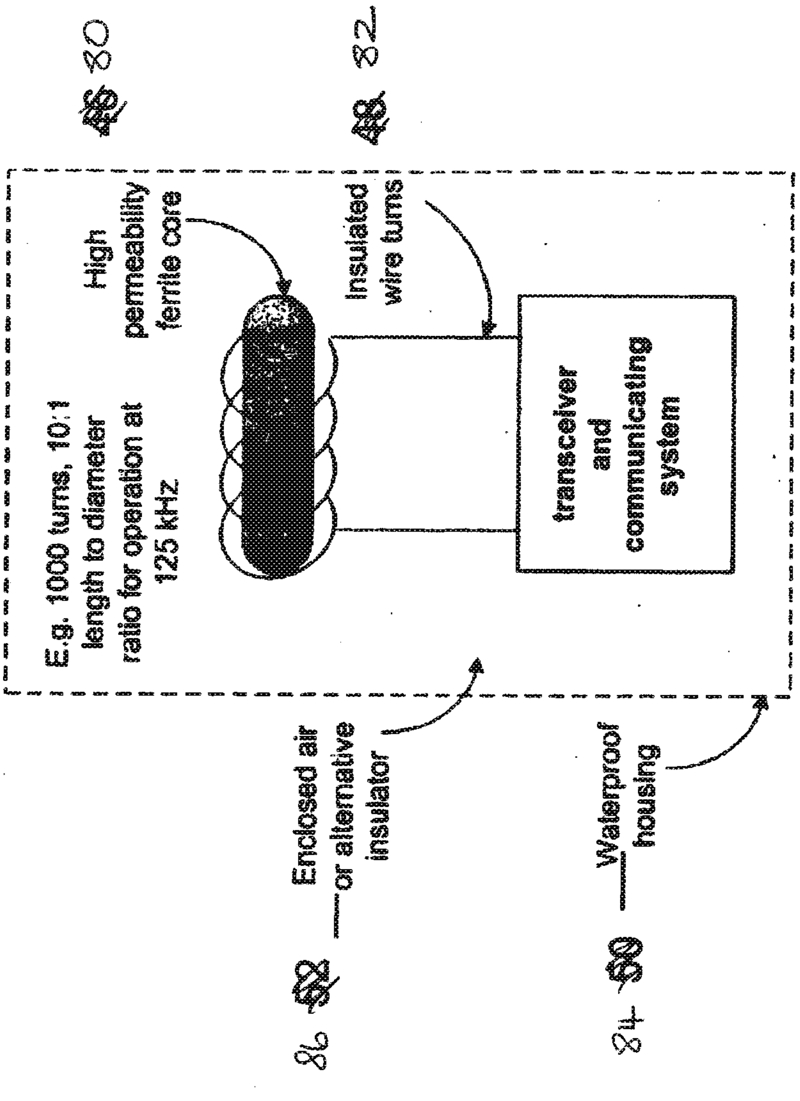
80
82
E.g. 1000 turns, 10:1 length to diameter ratio for operation at 125 kHz
High permeability ferrite core
Insulated wire turns
transceiver and communicating system
Enclosed air or alternative insulator
Waterproof housing
86
84

Figure 3

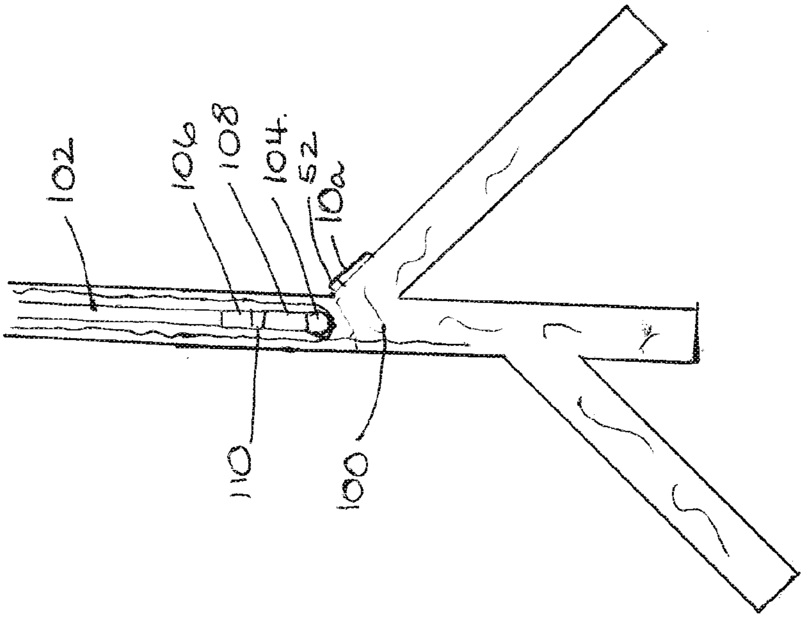

FIGURE 5

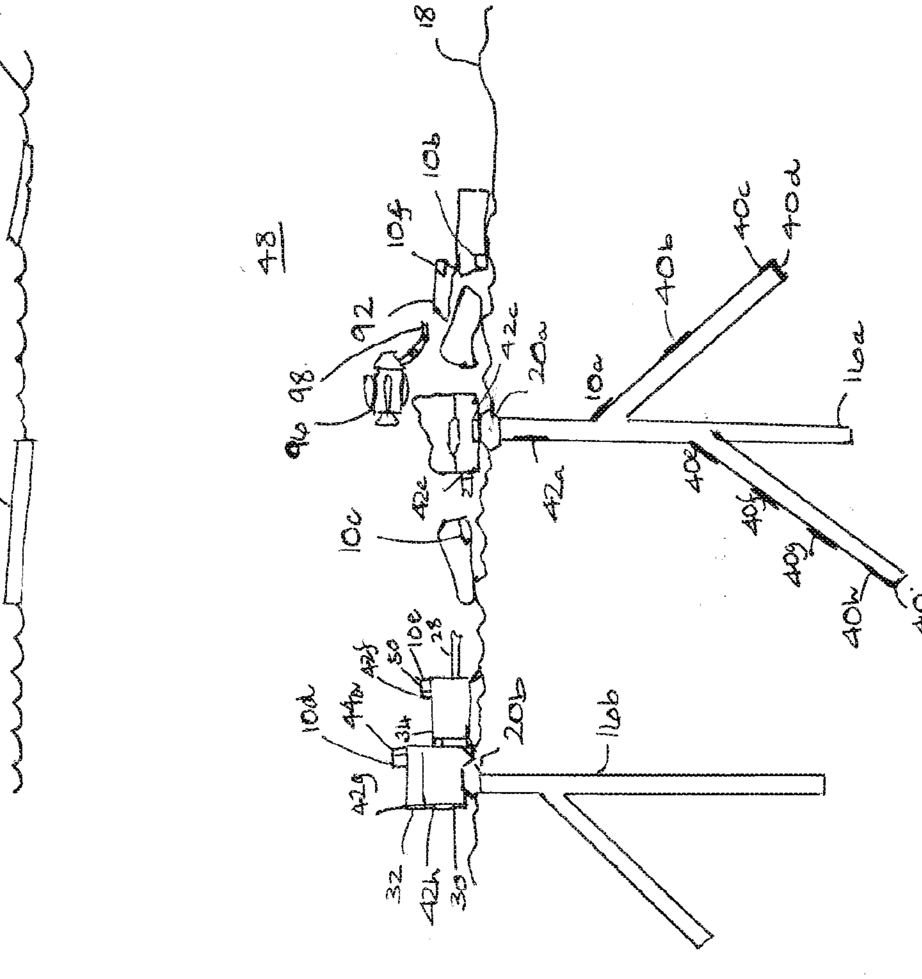

FIGURE 4.