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INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 6 : G01V 3/08

A1

(11) International Publication Number: WO 99/00679

(43) International Publication Date: 7 January 1999 (07.01.99)

(21) International Application Number: PCT/GB98/01881

(22) International Filing Date: 26 June 1998 (26.06.98)

(30) Priority Data:
9713573.5 26 June 1997 (26.06.97) GB

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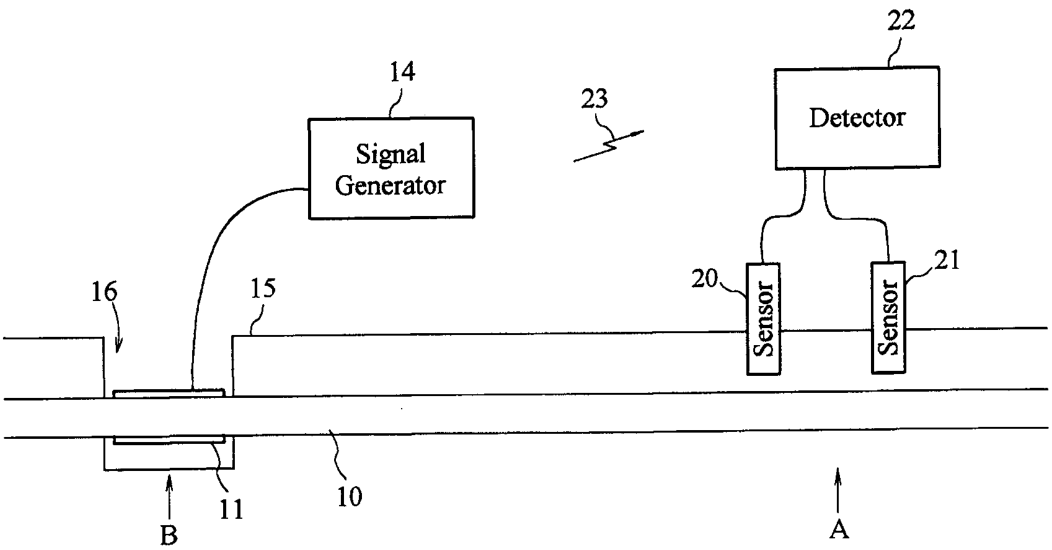
(81) Designated States: GB, JP, US, European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE).

Published
With international search report.
Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.

(54) Title: DETECTING UNDERGROUND PIPES



(57) Abstract

Pressure waves are generated in a pipe (10) containing a dielectric fluid, by providing at least one electrode (11) adjacent to the pipe (10) and means (14) for applying a varying electric signal to the electrode (11) to generate a varying electric field in that pipe (10). The electric field is of a magnitude sufficient to create dipoles in the molecules of the dielectric fluid, and pressure waves are created by the creation and relaxation of these dipoles. A detector (20, 21, 22) detects the pressure waves in the pipe (10) at a point remote from the electrode (11), so enabling the pipe (10) to be detected underground.

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DETECTING UNDERGROUND PIPES

BACKGROUND OF THE INVENTION

FIELD OF THE INVENTION

The present invention relates to the detection of a pipe by means of pressure waves in the pipe.

SUMMARY OF THE PRIOR ART

US-A-5269335 discloses a method of detecting a buried pipe, in which pressure waves were generated in the pipe. Those pressure waves passed down the pipe and outwardly of the pipe. They could therefore be detected by sensors adjacent to the ground surface. By providing two sensors, at spaced apart locations, it was possible to determine the location of the pipe relative to the sensors, and a reference sensor could be used to allow distance measurement along the pipe by monitoring the change in energy levels of the pressure waves detected.

In US-A-5269335, the pressure waves in the pipe were generated by a valve which controlled the flow of water in the pipe. Thus by causing the water to intermittently flow and be shut off, a water hammer effect was generated in the pipe, thereby generating the pressure waves.

This method has the disadvantages that a water flow is needed in the pipe, and that the normal operation of the pipe has to be interrupted.

US-A-5553498, discloses a method of detecting a buried pipe , in which it is the pipe itself which is excited, by a vibration device attached to its wall. The vibrating pipe is detected in a similar way to US-A-5269335. Although this method does not require an interruption of the normal operation of the pipe, it does impose a large strain on the pipe at the vibration site.

SUMMARY OF THE INVENTION

The present invention proposes that a dielectric fluid in a pipe made of insulating material is excited by the generation of a pulsed or alternating electric field in the pipe. The field is generated by at least one electrode adjacent the pipe, to which is applied pulsed or alternating electric signals. The preferred dielectric fluid is fuel gas, although any other fluid with appropriate dielectric properties could be carried in the pipe to be located.

The electric field creates a dipole in the molecules, which repel each other. This repulsion, which is repeated due to the pulsing of the electric field, causes pressure waves, e.g. acoustic waves, in the fluid in the pipe which can be detected at a point removed from the location of the electrode. The detection arrangement may be similar to that used in US-A-5269335, or any other suitable detection arrangement. In this invention the pressure waves are generated by the at least one electrode.

The at least one electrodes are conveniently provided in an assembly where they are encased in an insulating material and insulated from each other, if more than one is present. If a single electrode is used, the signal is generated relative to ground, using the part of the pipe not adjacent the electrodes as ground. However, if more than one electrode is used to form an electrode assembly, a signal return path may be defined from the electrodes. The electrodes may be arranged along the length of the pipe, or be arranged on opposite sides of the pipe. With a plurality of electrodes, and appropriate signal generation a travelling or "peristaltic" wave can be set up in the fluid in the pipe.

The electrode assembly may be of an suitable shape to be placed adjacent the pipe, although one preferred arrangement is for the assembly to be in the two-part annular form which completely surrounds the pipe.

The signal characteristics of the applied electric signal are usually discrete pulses at regular intervals, i.e. a square wave, with a frequency of about 300Hz. However, the signal applied may take another form and/or be modulated so that a different signal characteristic may be assigned to each pipe which is to be located.

It should be noted that, where the dielectric fluid is a gas, such as fuel gas, the magnitude of the electric field should be less than that magnitude which would cause electrical discharge in, or ionisation of, the gas.

BRIEF DESCRIPTION OF THE DRAWINGS

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

Fig. 1 shows a schematic view of the operation of a locator embodying the present invention;

Fig. 2 shows in more detail the electrode assembly of Fig. 1; and

Fig. 3 shows an alternative construction of the electrode assembly of Fig. 1; and

Fig. 4 shows in more detail the detector of the embodiment of Fig. 1.

DETAILED DESCRIPTION

Referring first to Fig. 1, a pipe 10 which is to be located at a remote site A is accessed from an access hole 16. This hole 16 may either be a standard access hole or one excavated especially for the purpose of this pipe location. An electrode assembly 11 is sited around the pipe 10 at a transmission site B, in the hole 16.

The electrode assembly 11 may also be placed on a standpipe or other similar pipe extending from the pipe 10 above the surface 15 of the ground. Another possible arrangement is for the electrode assembly 11 to be fitted to the pipe 10 before it is buried, with an electrical connection point for the electrode assembly 11 to be provided at a suitable location.

The electrode assembly 11 as illustrated is connected to a signal generator 14. In operation, the signal generator 14 sends a pulsed electric signal to the electrode assembly 11, which generates a pulsed electric field in the pipe 10. A signal return path from the electrode assembly 11 to the signal generator 14 is also present.

The pulsed electric field causes pressure waves in the fluid in the pipe 10. Pressure waves therefore move outwardly from the site B. The main path of transmission is through the fluid in the pipe 10 but some vibrational energy will radiate outwardly from the pipe 10 along its length.

As a result, sensors 20 and 21 at the detection site A will be able to sense vibrational energy transmitted from the pipe 10 through the ground. The sensors 20, 21 may thus be mounted close to the surface 15 of the ground. The sensors 20, 21 pass signals to a detector 22, and the analysis of those signals enable an operator to determine whether the pipe has been located correctly. Whilst the presence of the pipe carrying the vibrational energy can be detected by one sensor 20, 21, the use of two sensors enables the location of the pipe 10 at the detection site A to be determined more accurately. If it is found that the sensors 20, 21 are aligned with the pipe, and spaced along it, it may also be possible to determine the distance between the detection site A and the transmission site B by the change in vibrational energy levels between the sensors 20, 21. Alternatively, a further sensor (not shown) may be provided connected at detector 22, but spaced between the detection site A and the transmission site B.

The signal from the signal generator 14 may generate a simple pulsed electric signal, i.e. a square wave. However, if desired, a modulation may be applied to enable different pipes to be identified. In such circumstances, it may be useful for the signal generator 14 to signal its modulation to the detector 22, shown by arrow 23.

Fig. 2 illustrates a construction of the electrode assembly 11. The assembly 11 contains three electrodes 13A, 13B, 13C which are encased in insulating material 12. The central electrode 13B receives the generated signal from the signal generator 14, and the outer electrodes 13A, 13C, which are electrically connected together, form the start of the return path to the signal generator 14. The insulating material 12 is thick enough to prevent its dielectric breakdown on the application of te electric signal across the electrodes 13A, 13B, 13C.

The assembly 11 is provided in a two part annular form, designed to completely encompass the pipe 10. The two parts are connected together by standard means such that each of the electrodes 13A, 13B, 13C forms a complete ring about the pipe 10. However, another or of the electrode assembly envisaged is a flexible sleeve of insulating material containing flexible electrodes, so that the electrode assembly can fit round pipes of varying diameters, being secured in place by straps or the like.

Fig. 3 illustrates an alternative construction for the electrode assembly 51. In this embodiment, the assembly 51 has two parts 51A, 51B disposed diametrically opposite each other, which are linked to the signal generator 14 as in Fig. 2. The electric field produced is therefore directed across the pipe 10 within the length of the electrode assembly 51. Each of the two parts 51A, 51B has one electrode 53A, 53B, encased in an insulation layer 52A, 52B. The two parts 51A, 51B of the electrode assembly 51 are of a suitable axial length to produce the desired results.

The signal applied by the signal generator should have a frequency preferably in the low audio hand e.g. 300Hz, and in the form of a pulsed signal, i.e. a square wave. As mentioned above, the signal may be take another form and/or modulated to make the location of a number of pipes easier to differentiate. The size of the signal may be any suitable voltage, although 10kV or more is preferred.

Referring now to Fig. 4, the detector 22 has an analog input 41 connected to each of the sensors 20, 21. Each sensor 20, 21 includes a geophone 43. Only one geophone 43 is shown in Fig. 3, but there will be one for each sensor 20, 21. The geophone 43 passes signals to the input 41, and from there to a processing unit 46. Power for the detector 22 is obtained from a battery pack 47, power from which is passed by a power control unit 48 to the processing unit 46 and the input 41. The processing unit 46 also controls the power control unit 48. The processing unit 46 uses a program stored in a memory 49 to analyse the signals from the geophone 43 to generate a display which displayed on a display unit 50 to indicate the results of the detection of the acoustic waves. The processing unit 46 may also have as an input the modulation 23 (not shown) applied by the signal generator 14, so as to ensure the location of the correct pipe. A key pad 51 permits the user to input commands to the processing unit 46 and to the power control unit 48.

CLAIMS

1. A device for generating pressure waves in a pipe containing a dielectric fluid, comprising at least one electrode located adjacent the pipe and means for applying a varying electric signal to said electrode so as to generate a varying electric field in the pipe, at least the maximum value of the electric field being sufficient to create dipoles in the molecular of the dielectric fluid, the pressure waves being generated by the creation and relaxation of these dipoles.

2. A device according to claim 1, having two electrodes, with the signal being applied between the electrodes.

3. A device according to claim 2, wherein each of said electrodes is curved so as to conform to the pipe, the electrodes forming a broken annulus around the pipe.

4. A device according to claim 1 having a single electrode, with the signal being applied between the electrode and ground.

5. A device according to any one of the preceding claims, wherein the at least one electrode is encased in insulating material.

6. An apparatus for detecting a pipe comprising a

device according to any one of the preceding claims mounted on the pipe, and at least one detector for detecting the pressure waves in the pipe at a point remote from the electrode.

7. A method of generating pressure waves in a pipe containing a dielectric fluid, in which a varying electric signal is generated in the pipe so as to generate a varying electric field in the pipe, at least the maximum value of the electric field being sufficient to create molecular dipoles in the dielectric fluid, so that pressure waves are generated by the creation and relaxation of those dipoles.

8. A method of detecting a buried pipe containing a dielectric fluid, the method comprising:

generating pressure waves at a first point in the pipe by generating a varying electric signal in the pipe, so as to generate a varying electric field in the pipe, at least the maximum value of the electric field being sufficient to create molecular dipoles in the dielectric fluid, so that so that pressure waves are generated by the creation and relaxation of those dipoles; and

detecting the pressure waves in the pipe at a second point remote from the first point.

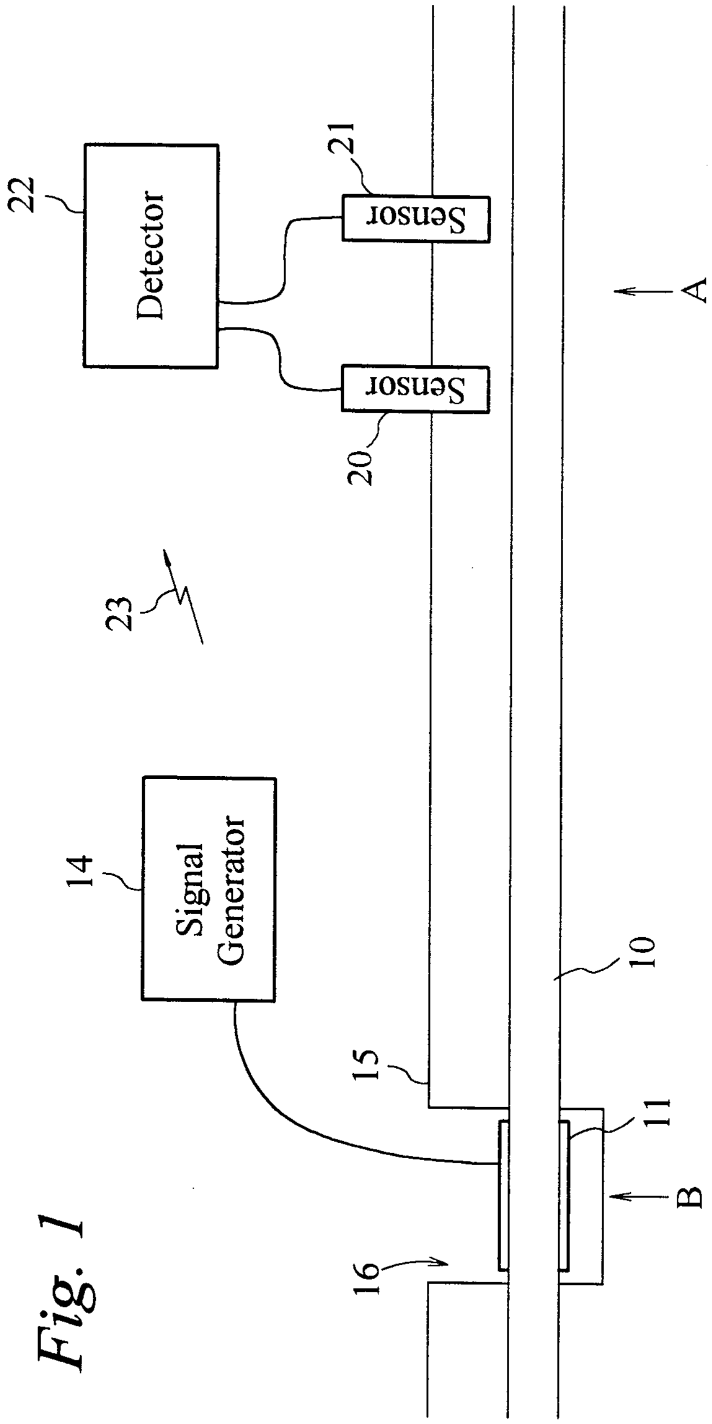

22
Detector
21
Sensor
20
Sensor
A
23
14
Signal Generator
10
15
11
B
16

Fig. 1

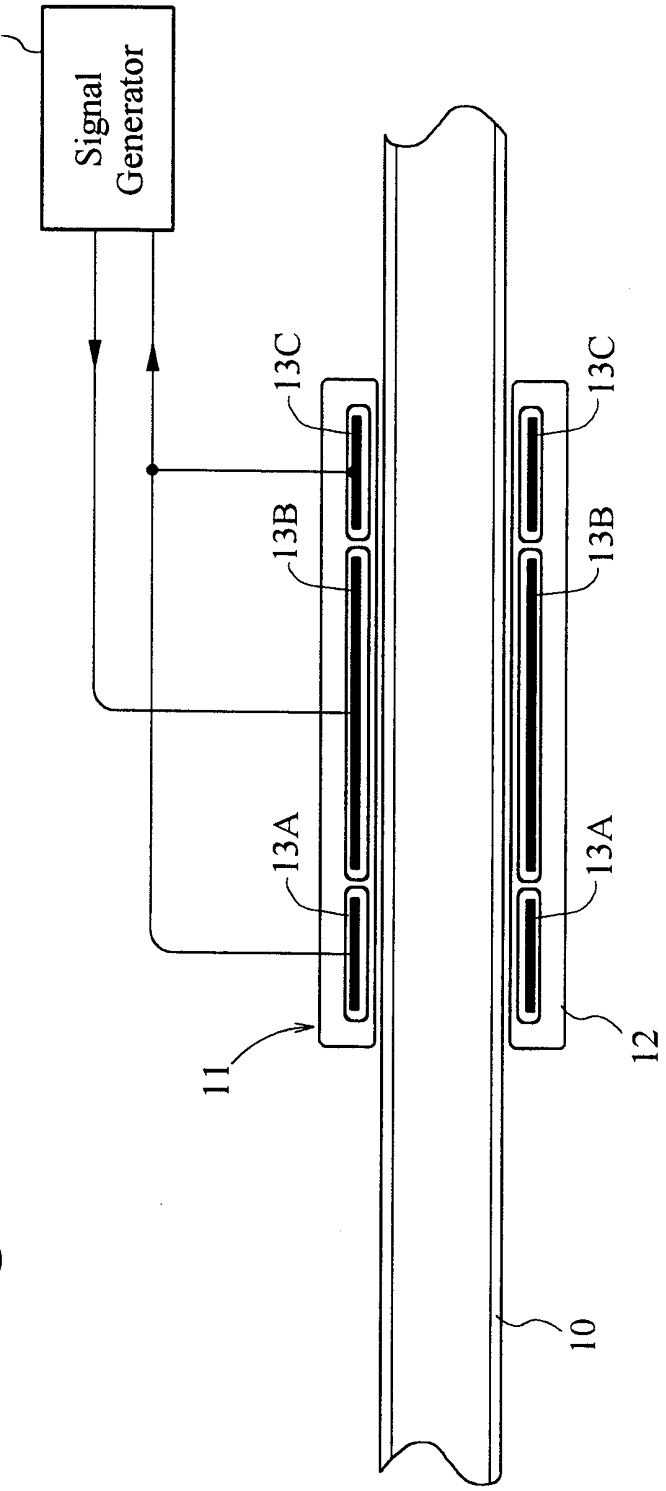
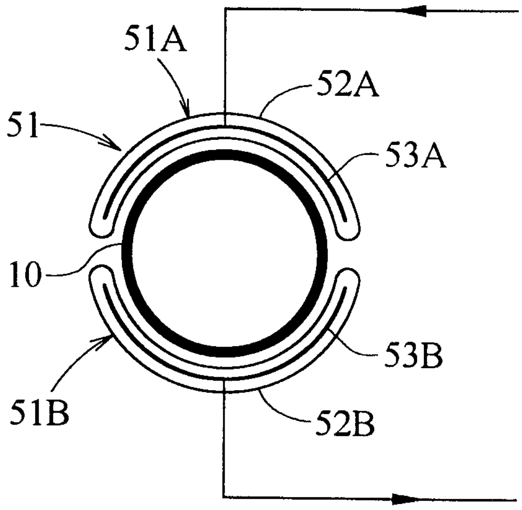


Fig. 2

Fig. 3



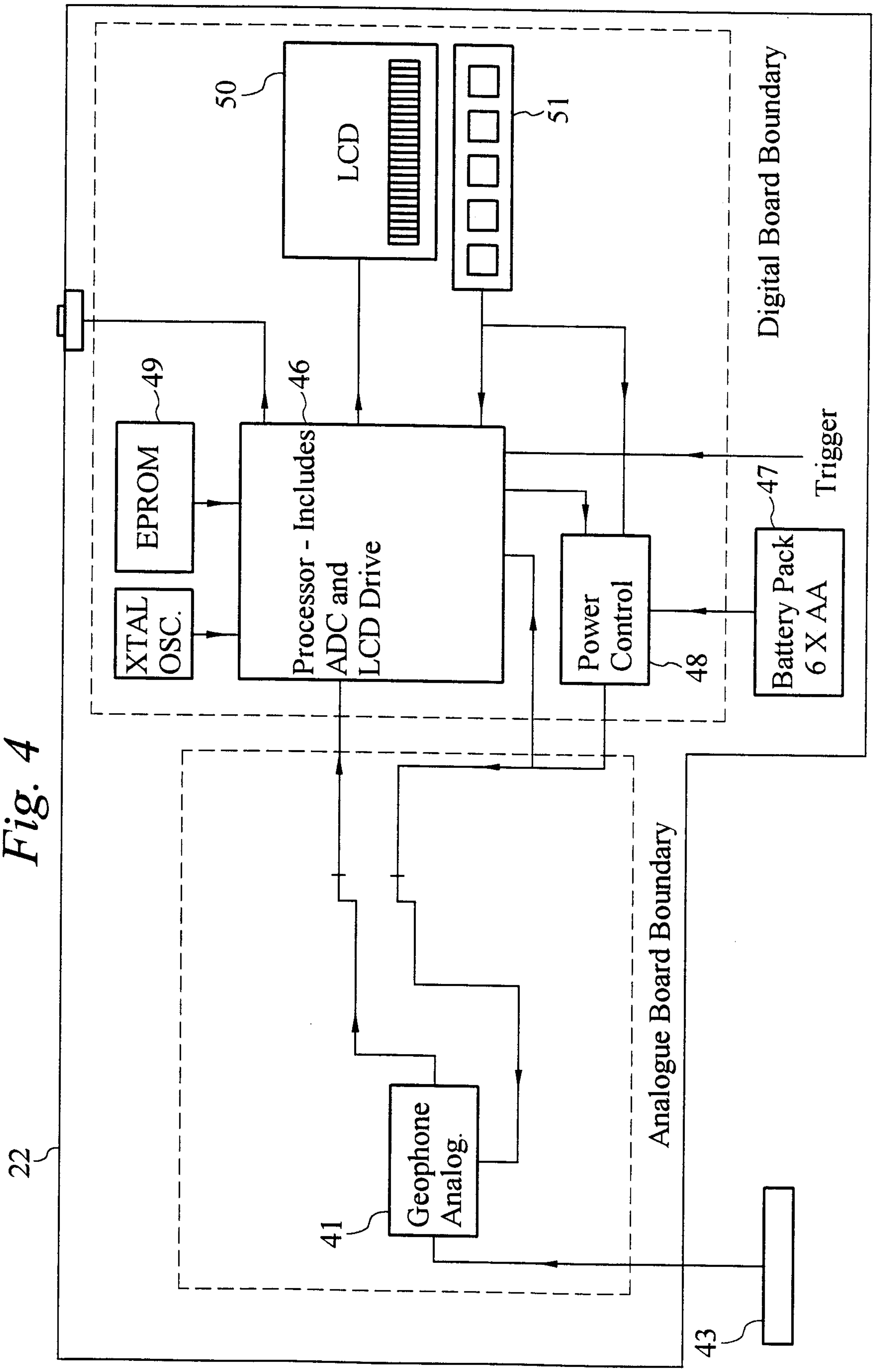

50
LCD
51
Digital Board Boundary
49
EPROM
46
Processor - Includes ADC and LCD Drive
XTAL OSC.
Trigger
47
Power Control
48
Battery Pack 6 X AA
Analogue Board Boundary
Geophone Analog.
41
22
43

Fig. 4

INTERNATIONAL SEARCH REPORT

International Application No
PCT/GB 98/01881

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 G01V3/08

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 6 G01V G10K G01F

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

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 0 512 756 A (EXXON PRODUCTION RESEARCH CO) 11 November 1992 see column 3, line 28 - column 4, line 42 see column 7, line 2 - line 27 see column 10, line 34 - line 45 see claim 1 see figures 1-5 ---	1,7
A	US 5 269 335 A (HEITMAN LYNN B) 14 December 1993 cited in the application see the whole document -----	1

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

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17 November 1998	30/11/1998

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No

PCT/GB 98/01881

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