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(71) Applicant
David Lovett Ewbank Teal,
1 The Weald, Ashford, Kent TN24 8RA

(72) Inventor
David Lovett Ewbank Teal

(74) Agent and/or Address for Service
Elkington and Fife, High Holborn House, 52/54 High Holborn, London WC1V 6SH

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(58) Field of search
H4L
Selected US specifications from IPC sub-class H04B

(54) Transmitting measurement data electrically via earth medium

(57) Transducers 13 sensing the values of geotechnical parameters are coupled to and buried with a self-contained battery powered encoding and transmitting device 20. The coded electrical signal is applied across a pair of electrodes 3 which set up an electric potential field extending to the ground surface. A receiving unit equipped with a second pair of earthed electrodes 4 for receiving the transmitted signal, discriminates and interfaces the signal for data logging. The link enables the state of stress within the body of any earthworks to be monitored. A timing device limits the operation of the transmitter to brief periods at regular intervals. The data link is immune for accidential or malicious damage and enables construction work to proceed unimpaired by the presence of physical connections between the sensor and the measuring instrument.

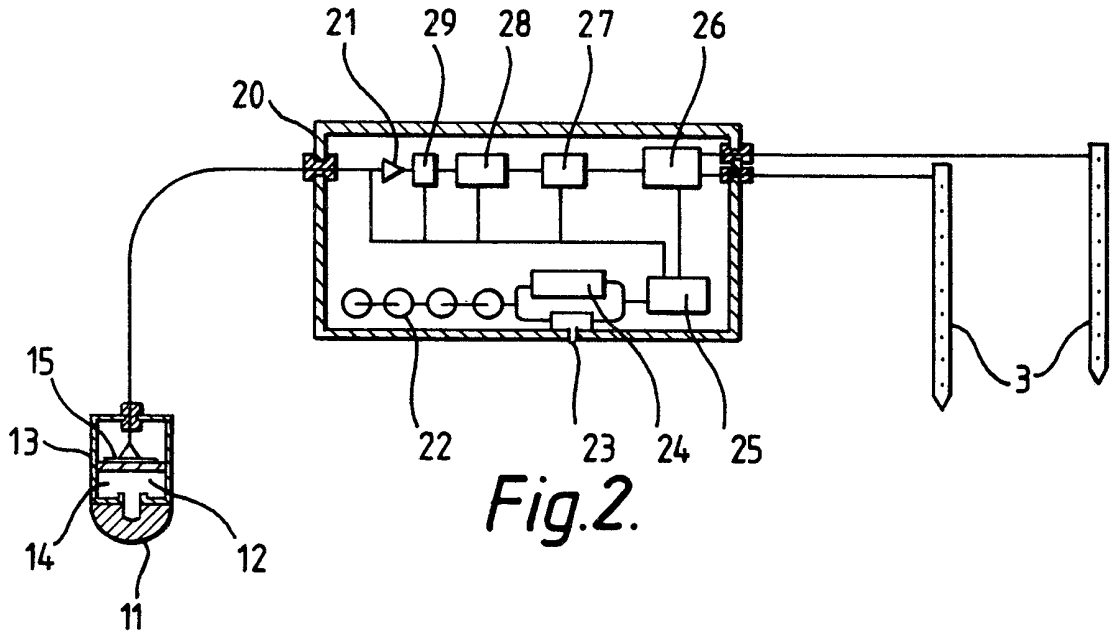

Fig.2.

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The drawings originally filed were informal and the print here reproduced is taken from a later filed formal copy.

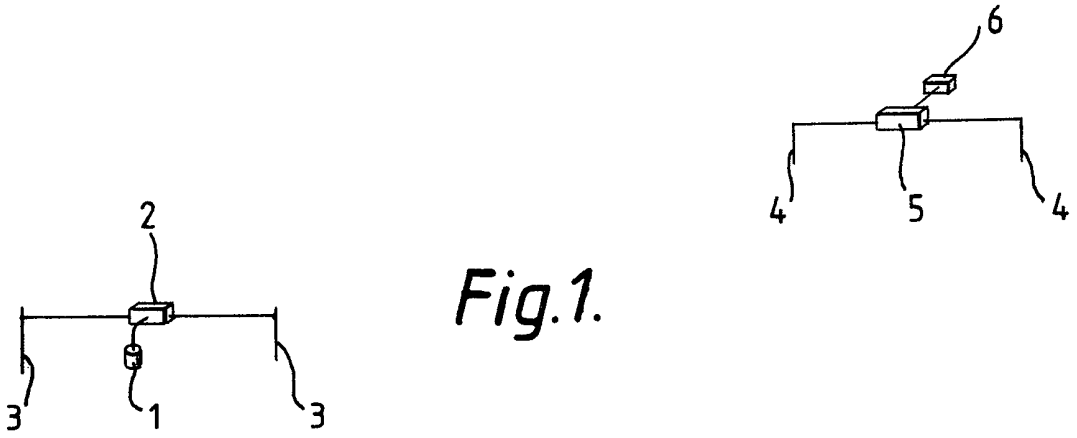

Fig.1.

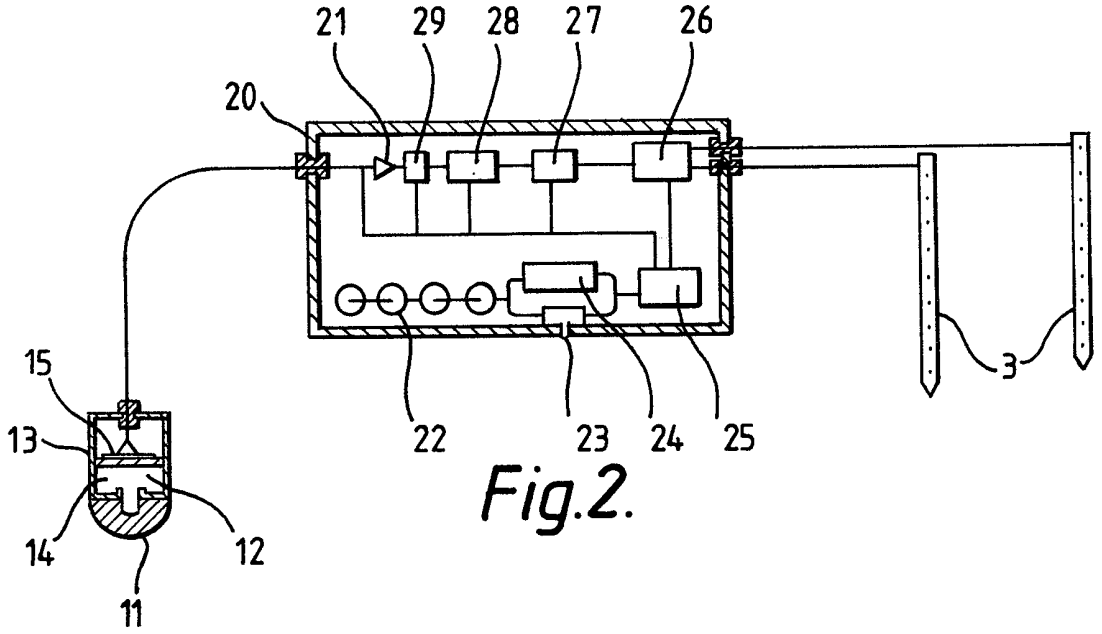

Fig.2.

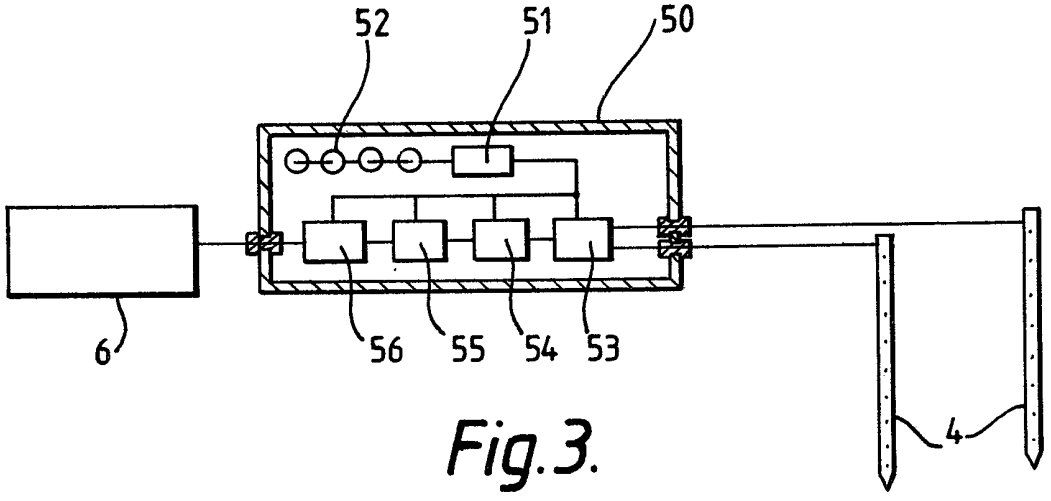

Fig.3.

SPECIFICATION

Geotechnical data link

This invention relates to the acquisition, transmission and retrieval of geotechnical data from within earthworks and foundations, and more particularly to apparatus for a cordless geotechnical data link.

Modern good practice in civil engineering earthworks such as dams, embankments, excavations, mines and foundations requires that the conditions existing in the ground should be monitored. It is customary to measure such parameters as pore water pressure, total stress, strain and rotation in each direction and temperature using suitable buried sensors connected to measuring instruments on the ground surface. The means of connection are electric wire, hydraulic or pneumatic tubing. The installation of such connections is frequently costly and disruptive to adjacent construction works. The connections are also vulnerable to accidental and malicious damage while the protective bedding around cables or pipes represents an undesirable discontinuity in the earth structure.

According to the present invention there is provided an alternative means for transmitting ground condition data without recourse to wires or tubes. The invention provides apparatus for transmission and reception of geotechnical data, comprising:

(a) transmitter means adapted to be buried in the ground, comprising a sensor for detecting changes in a geotechnical parameter, electrodes in contact with the ground, and means for converting a signal from the sensor into a corresponding alternating electric potential field between the electrodes; and

(b) receiver means for remotely receiving the signal transmitted by the transmitter means, and comprising electrodes in contact with the ground, a data logger and means for converting the signal received by the electrodes into a form suitable for reception by the data logger.

The values of the sensed parameters are converted to a coded electrical signal by means of the electronic circuits herein described. This signal is applied across a pair of electrodes in contact with the ground adjacent to the sensor location. An alternating electric field is thus established between the electrodes and extending in all directions. At the data receiving station on the ground surface, a further pair of electrodes in contact with the ground serves to relay the coded signal to the monitoring unit.

A specific embodiment of the invention will now be described by way of example with reference to the accompanying drawing in which:—

Figure 1 shows in perspective the relative locations of the various components of the system;

Figure 2 illustrates the arrangement of the buried components comprising filtered pressure transducer, transmitter enclosure with essential internal devices and the transmitting electrodes; and

Figure 3 illustrates the data receiving and monitoring station.

Referring to the drawings, piezometric sensor 1 relays in electrical analogue form the absolute value of pore water pressure to the transmitter 2. Transmitter 2 converts this value into a digitally coded and amplified signal which is connected across electrodes 3. An alternating electric potential field is established between the electrodes 3 and extending in all directions to encompass receiving electrodes 4. The attenuated signal received by electrodes 4 is relayed to receiving unit 5 where it is filtered, amplified and interfaced with data logger 6.

The pressure of the pore water in the soil is transferred through porous ceramic filter 11 while the force exerted by the solid soil particles is restrained by it. The size of the openings in the filter 11 is approximately one micrometer which will prevent the ingress of any gas present in the soil. Cavity 12 as well as the pore space in the filter 11 is filled by pure water with no dissolved gasses. Elastic diaphragm 14 is secured within rigid cylindrical enclosure 13 and incorporates four elastic resistive elements 15 arranged in wheatstone bridge configuration. When an electric current is passed through the elastic resistors 15 the ratio of voltages existing at the points of connection is a linear function of the strain in the elastic diaphragm 14 and hence of the pressure in cavity 12. The components 12, 13, 14, 15 may together be a "Shape" transducer type SP 1020/A.

The voltage analogue signal is connected to conditioning/amplifier 21 within rigid enclosure 20. The output signal is converted to digital binary form by 8 bit A—D converter 29 (giving a resolution of 1 in 256), controlled by low power CMOS microprocessor 28 and encoded by tone coding unit 27 into a series of tones representing logic zero and logic one (AFSK data). The signal is then amplified by narrow band audio frequency amplifier 26 and applied across transmitting electrodes 3. Electric power is provided by a battery of cells 22 and voltage regulator 25. In order to conserve the available energy, XTAL timer and power switch 24 working on unregulated voltage is arranged to switch on the other components for a brief period at daily intervals. Manual by-pass switch 23 allows the installation to be tested independently of the timer before being covered up. The switch is resin-sealed after testing is complete. By using lithium sulphur dioxide cells e.g. Duracell type LO28SX as the power source an operating life of ten years is expected. The amplified signal applied to the electrodes has a peak potential of twelve volts and a maximum current of two hundred milliamperes.

A feature of the transmitting electrodes 3 and the receiving electrodes 4 is their low-resistance connection with the ground. They are made from hollow copper tubing perforated with fine holes and filled with copper sulphate crystals. Immediately after installation, water is added to the tubes causing a saturated solution of copper sulphate to permeate the surrounding ground. The presence of ions locally in the groundwater reduces its resistance in that zone where the electric potential gradient is greatest.

Signals detected as small potential differences across receiving electrodes 4 are amplified by narrow bandpass pre-amplifier 53. Two phase locked loop decoders 54, one for each tone, permit only the two designated tones in the output to pass on to the tone to voltage converter 55 and, TTL digital to RS232C interface 56. Data logger 6 records the monitored data for later retrieval and can be any of those in common use, e.g. tape cassette, Eprom or paper chart. The narrow bandpass filtering provided by components 53 and 54 is required to remove mains borne or similar interference. Power for the receiving unit is provided by replaceable or rechargeable battery 52 and voltage regulator 51 housed in common enclosure 50.

Although only one sensor is described in this example, the electronic circuitry has the capacity to transmit up to four channels of data. Typically, one channel comprises a station identification code, leaving three channels for data from separate sensors of any type.

The tone frequencies and consequently the data baud rate are selected to ensure reliable operation in soils exhibiting capacitive and polarisation as well as resistive properties. A suitable serial baud rate is about 50 baud.

CLAIMS

1. Apparatus for transmission and reception of geotechnical data, comprising:

(a) transmitter means adapted to be buried in the ground, comprising a sensor for detecting changes in a geotechnical parameter, electrodes in contact with the ground, and means for converting a signal from the sensor into a corresponding alternating electric potential field between the electrodes; and

(b) receiver means for remotely receiving the signal transmitted by the transmitter means, and comprising electrodes in contact with the ground, a data logger, and means for converting the signal received by the electrodes into a form suitable for reception by the data logger.

2. Apparatus according to Claim 1, in which the sensor is a piezometric sensor adapted to relay in electrical analogue form the absolute value of pore water pressure.

3. Apparatus according to Claim 2, in which the transmitter means includes an amplifier and encoder adapted to convert the electrical analogue signal from the sensor into a digitally coded and amplified signal which is connected across the transmitter electrodes.

4. Apparatus according to any of Claims 1 to 3, in which the receiver means includes an amplifier for amplifying the signal detected by the receiver electrodes and a decoder for converting the amplified signal for reception by the data logger.

5. Apparatus according to any of Claims 1 to 4, in which the transmitter means includes a timer for actuating the apparatus at predetermined time intervals.

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