

[54] SOIL IMPEDANCE LOG

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[56] **References Cited**
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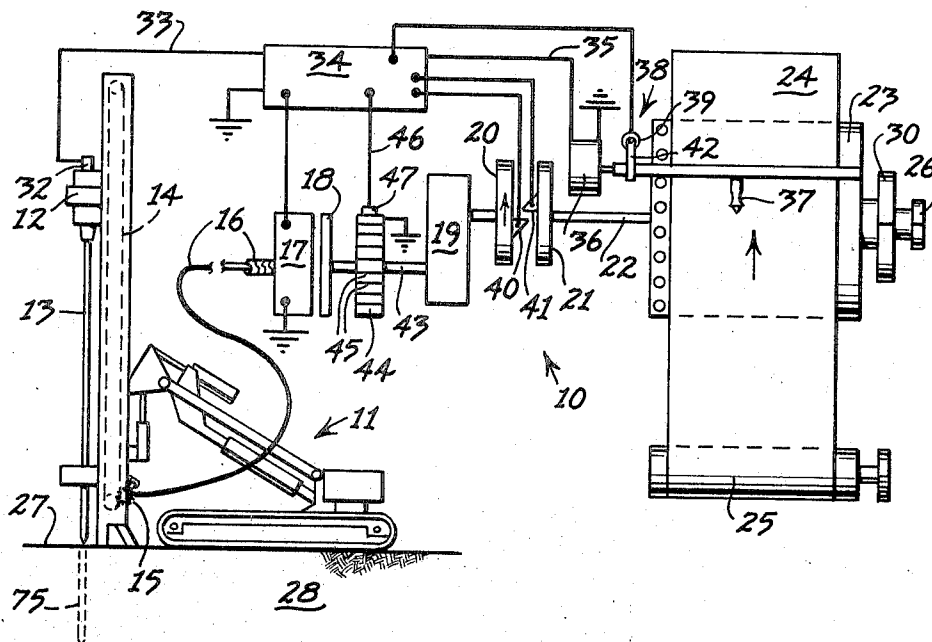
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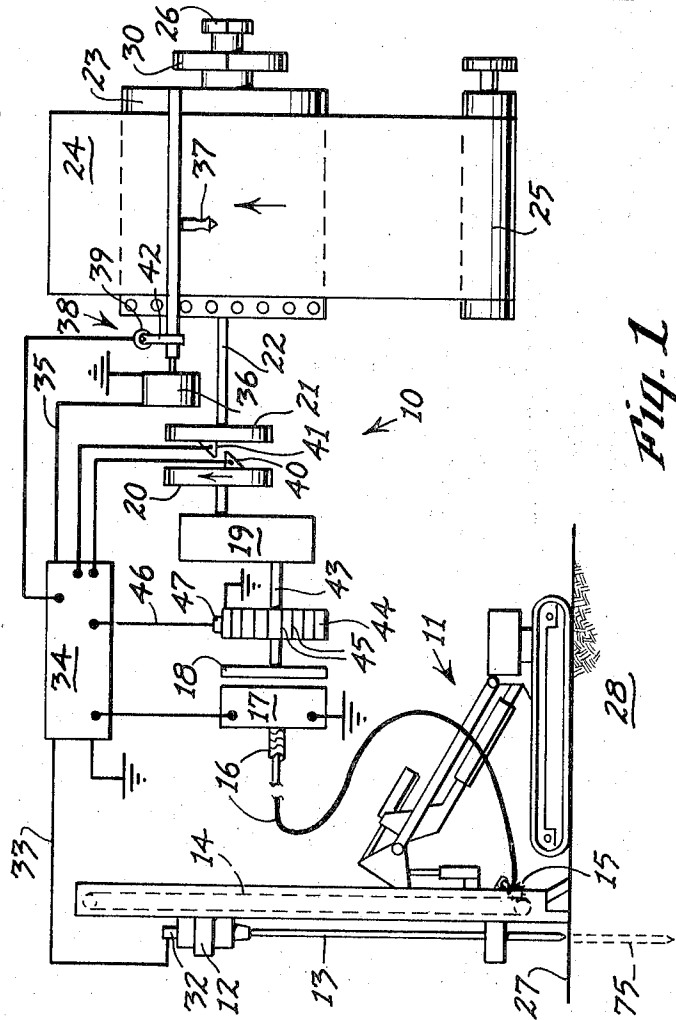
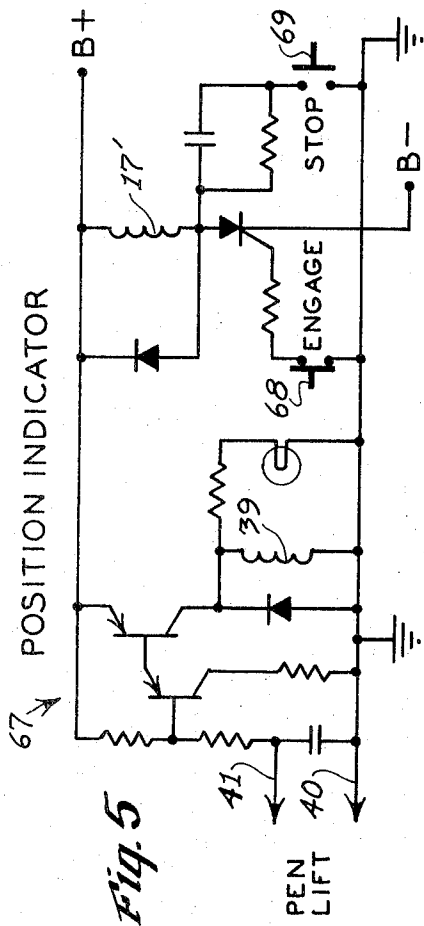
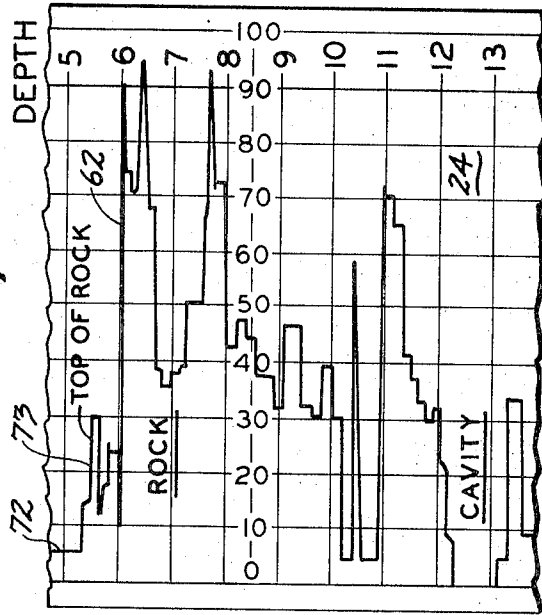
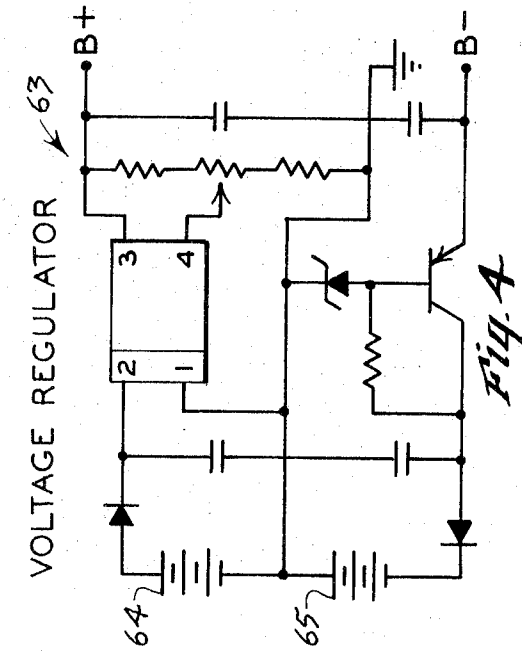
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[57] **ABSTRACT**

A soil impedance log operatively connected to a track drill, including a transducer for sensing the number of hammer blows upon the drill rod, an electrical system for processing, accumulating and periodically counting the hammer signals for each successive uniform depth of penetration, and recording means operatively connected to the track drill for visually indicating the comparison of the number of hammer blows per unit depth of penetration with the total depth of penetration.

10 Claims, 5 Drawing Figures





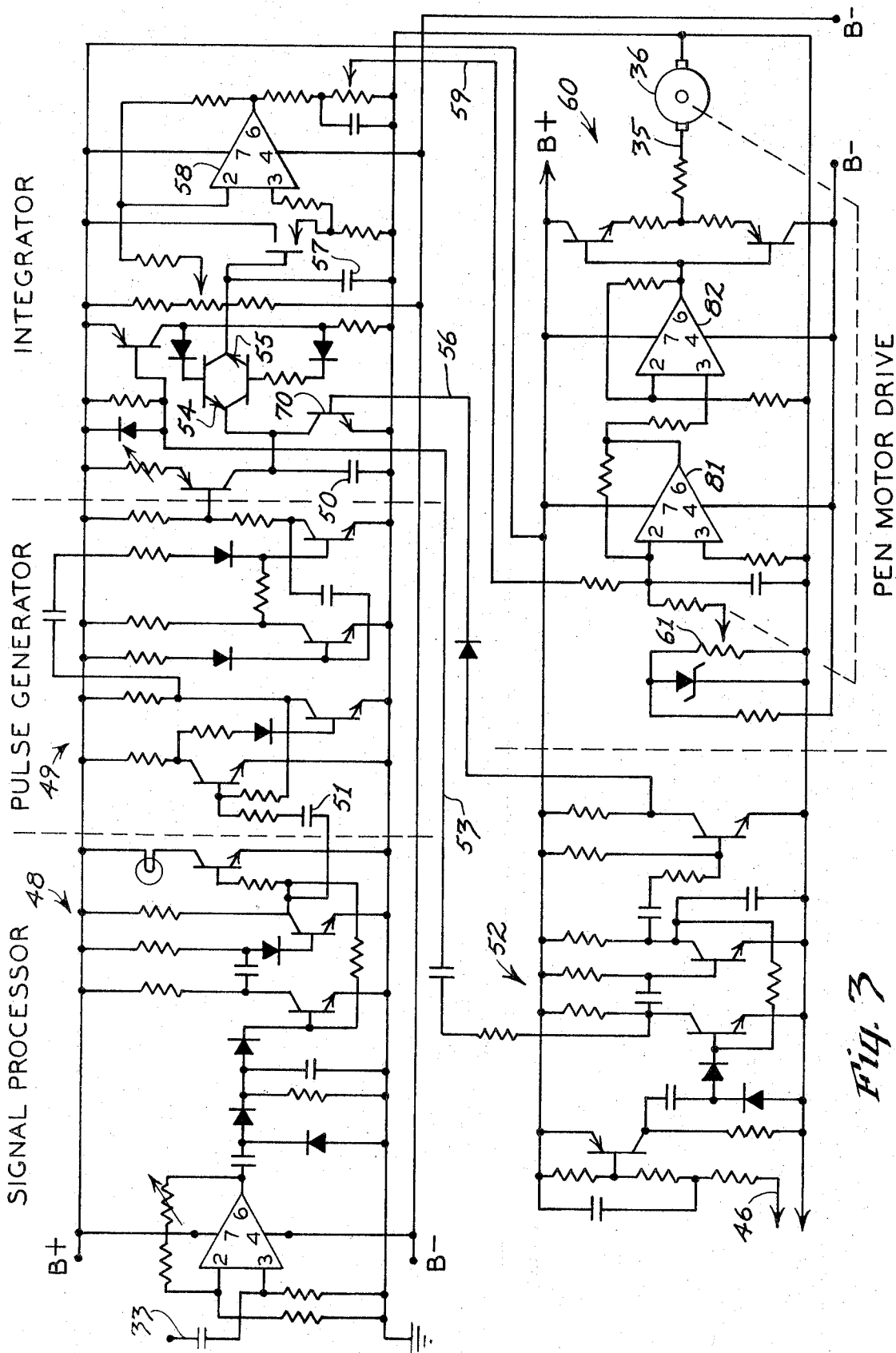


Fig. 3

SOIL IMPEDANCE LOG

BACKGROUND OF THE INVENTION

This invention relates to a soil impedance log, and more particularly to a soil impedance log for operation with a track drill.

There are several different methods for probing the subsurface of soil in order to determine its composition and hardness at various depths, primarily for the design of structural foundations. The most common method of probing the sub-surface is the utilization of a core drill, which extracts a core sample of the actual sub-surface soil to a given depth. Inspection and testing of the core sample reveals the stratification and composition of the soil for the surrounding area. Although the core drilling method of obtaining information regarding the composition of the sub-surface of the soil is very accurate, nevertheless it is a slow and expensive process.

Track drills are, of course, known in the art, but are utilized for drilling test holes and for the placement of explosives. Although the penetration of a track drill is ten times faster than core drilling, nevertheless it is not believed that track drilling has been utilized for the determination of the hardness, stratification or composition of sub-surface soil conditions.

SUMMARY OF THE INVENTION

It is therefore an object of this invention to provide a soil impedance log adapted to cooperate with a conventional track drill for accurately, quickly and economically determining the hardness of the soil at various levels of penetration of the track drill.

A sensing device, such as a transducer for converting mechanical vibrations into corresponding electrical signals, is mounted in any appropriate position upon the track drill for detecting the vibrations of the hammer blows upon the drill rod. The electrical signals from the transducer are processed into uniform current pulses which are stored in a capacitor. A commutator switch is designed to trigger the capacitor at the termination of each unit depth of penetration to produce an output voltage having a magnitude proportional to the number of blows per unit depth of travel of the drill rod. This output signal is integrated and compared with a reference voltage signal to produce an unbalanced voltage for energizing a pen motor. The pen motor drives a pen, or other scribing instrument, across a longitudinally moving sheet of graph paper a transverse distance proportional to the unbalanced voltage, which in turn is proportional to the number of hammer blows per unit depth of penetration, and consequently registers a graphic representation proportional to the hardness of the soil encountered. The graph paper is moved longitudinally a distance proportional to the total depth of penetration of the drill rod, so that the hardness for any depth of penetration is immediately recorded.

The apparatus may also be provided with electrical clutches and a unidirectional drive so that the log apparatus may be disconnected when the drill rod is retracted from its penetrating position, in order to inspect the drilling hole, to replace the drill rod, to clean the drill rod, or to add an extension to the drill rod.

The scribing pen is also provided with means for disabling or disengaging the pen from the graph paper so that no recording is effected, except when the drill rod is operative to penetrate the soil.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic view of the apparatus made in accordance with this invention, operatively connected to a conventional track drill;

FIG. 2 is an enlarged, fragmentary plan view of a portion of the graph paper illustrating the hardness of sub-soil at various depths;

FIG. 3 is a schematic circuit diagram of the electrical system for sensing the hammer blows on the drill track and for driving the pen motor;

FIG. 4 is the power supply circuit for the electrical system disclosed in FIG. 3; and

FIG. 5 is a schematic diagram of the position indicator electrical circuit.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to the drawings in more detail, FIG. 1 discloses schematically the apparatus 10 made in accordance with this invention, operatively connected to a conventional track drill 11, having a pneumatic hammer assembly 12 and a drill rod 13.

The chain drive 14 for the pneumatic hammer assembly 12, operatively drives a unidirectional take-off sprocket 15. The sprocket 15, in turn, drives, through a flexible linear cable 16, an electromagnetic clutch 17, a rotary distance proportional to the depth of penetration of the drill rod 13. The armature 18 of the electromagnetic clutch 17 is fixed to a driven shaft 43 coupled through a gear reducer 19 to unidirectional clutch discs 20 and 21. The unidirectional driven disc 21 is fixed to rotary shaft 22 supporting a rotary drum 23, which drives graph paper 24 in the longitudinal direction of the arrow illustrated in FIG. 1. The graph paper 24 is fed across the drum 23 from the paper supply roll 25. Drum shaft 22 is provided with a knob 26 which is set at "earth zero" when the bottom of the drill rod 13 rests upon the surface 27 of the soil 28.

The paper knob 30 is designed to rotate the drum 23 relative to the shaft 22 until the paper 24 is set at zero to register with the "earth zero" reading on the knob 26.

Mounted in vibration sensing relationship to the hammer assembly 12 is a transducer 32, such as an accelerometer, for sensing the vibrations created by the hammer blows upon the drill rod 13, and to convert such vibrations into electrical signals for transmission through the lead 33 to the electrical control system 34.

The output signal from the electrical circuit system 34 is transmitted through the output lead 35 to the electrical pen motor 36, which is adapted to drive the scribing instrument, or pen 37, transversely of the longitudinally moving graph paper 24. The pen 37 may be driven transversely by an endless belt and pulley transmission, not shown.

The pen 37 is also provided with a lifting device 38, including an electromagnet having a coil 39 and a lever arm 42 operatively connecting the electromagnet and the pen 37, for raising and lowering the pen 37 into disengagement and engagement with the graph paper 24. When the switch contacts 40 and 41 on the clutch teeth of the friction discs 20 and 21 are engaged or closed, the coil 39 is energized to lower the pen 37 into scribing contact with the graph paper 24. When the drive clutch disc 20 is counter-rotated, the contacts 40 and

41 are opened to cause the pen 37 to rise above the paper 2, by, for example, a spring, not shown.

Fixed upon the shaft 43 between the magnetic armature 18 and the gear reducer 19 is a rotary commutator 44, upon the periphery of which are uniformly spaced circumferentially, a plurality of electrical contacts 45 which are connected through lead 46 into electrical control system 34.

FIG. 3 discloses some of the electrical circuitry contained within the electrical control system 34. Each electrical signal sensed by the transducer 32 is transmitted through the input lead 33 into the signal processor circuit 48, where the signal is shaped into square waves. The square waves from the processor circuit 48 then become periodic spike signals as they pass through the coupling capacitor 51 and are fed to the pulse generator circuit 49. In the pulse generator circuit 49, the signals are shaped into periodic current pulses of uniform height and width.

For each successive hammer blow, a current pulse is produced by the pulse generator 49 and stored and accumulated in the capacitor 50. The voltage wave form across capacitor 50 is that of a stair-step generator.

After the rotary commutator 44 has been rotated one increment until the first commutator bar or contact 45 is engaged by the brush 47, current is transmitted through the lead 46 to energize the trigger circuit 52, resulting in an output signal through the lead 53, which energizes the transistors 54 and 55 to transfer a portion of the stored charge from the first capacitor 50 to the second capacitor 57. Subsequently, a delayed signal is transmitted from the trigger circuit 52 through discharge lead 56 to de-energize the transistors 54 and 55 and to energize or close switch transistor 70. The remaining charge on capacitor 50 then discharges to ground through the closed transistor 70. After the first capacitor 50 has completely discharged, it commences "counting," or receiving and accumulating additional current pulses from the pulse generator circuit 49, upon subsequent hammer blows occurring during the next increment of penetration of the drill rod 13.

In the meantime, the first stored charge transmitted to the capacitor 57 is processed in the amplifier circuit 58, producing an integrated signal which is transmitted through the lead 59 to the pen motor drive circuit 60. The output signal in the circuit 59 is compared with a reference voltage signal across the reference potentiometer 61, and the unbalanced voltage signal is further processed in amplifier circuits 81 and 82, and transmitted through the lead 35 to the pen motor 36, which is driven until the reference voltage signal at the potentiometer 61 is in balance with the output signal from the lead 59. The pen motor 36 correspondingly drives the pen 37 across the longitudinally moving graph paper 24 to inscribe a line, such as 62, of a length corresponding to the hardness of the soil through which the drill rod 13 penetrates.

FIG. 4 discloses the power supply and regulator circuit 63, including batteries 64 and 65, preferably of equal voltage, e.g. 12.6 volts.

FIG. 5 discloses the position indicator circuit 67, including the pen lift contacts 40 and 41, the pen lift electromagnetic coil 39 and the electromagnetic drive clutch coil 17. The circuit 67 also includes a start switch button contact 68 and a stop switch button contact 69.

In the operation of the apparatus 10, the drill rod 13 is positioned with its point on the soil surface 27 and the knob 26 is turned to its "earth zero" position. The knob 30 is then turned until the paper 24 has its zero depth line coinciding with the pen 37.

The start button 68 is depressed to close the circuit across the clutch coil 17' (FIG. 5), energizing the electromagnetic clutch 17 to engage its armature 18 (FIG. 1). As the track drill 11 is started, the hammer assembly 12 periodically hammers the top of the drill rod 13, forcing the drill rod to penetrate the surface 27. If the surface 27 and the soil 28 immediately below the surface, are soft dirt, the first hammer blow will cause the drill rod 13 to penetrate a considerable distance into the soil 28. This first hammer blow is sensed by the transducer 32, which transmits the input signal through the line 33 for processing in the circuits 48 and 49. The resulting signal is then stored in the first capacitor 50.

As illustrated in FIG. 2, the graph paper 24 has along its right edge a column of numbers representing the depth of penetration of the drill rod 13 in feet. Spanning the width of the graph paper 24 from left to right is a series of numbers from 0 to 100 which designate the number of hammer blows upon the drill rod 13. The initial portion 72 of the line 62, viewed at the top of the fragmentary graph paper 24 illustrates a penetration of approximately five hammer blows per inch at a depth of five feet, suggesting that at a depth of five feet the ground is probably dirt since it is relatively soft. However, as the depth of penetration of the drill rod approximates five and half feet, the line segment 73 reveals as many as 30 blows per inch, to show that the soil encountered is relatively harder, and is probably rock. The long line segment 62 illustrates very hard rock, indicating 100 blows per inch experienced at the six-foot level.

When the drill rod 13 is at the five-foot level, as illustrated by the line segment 72 in the graph paper 24 of FIG. 2, and very few blows are hammered upon the drill rod per inch, then only a few current impulses will be stored in the first capacitor 50, before they are transferred by the closing of the rotary commutator contacts 45 and 47. Accordingly, a low input voltage is impressed upon the second capacitor 57, which ultimately sends a low magnitude voltage signal to drive the pen 37 only a short transverse distance across the graph paper 24 as illustrated by the line segment 72.

On the other hand, when the drill rod 13 encounters hard rock, and numerous blows upon the drill rod 13 are developed for each inch of travel of the drill rod 13, then a high number of pulses will be accumulated to generate a high-magnitude voltage across the first capacitor 50 before the capacitor 50 is triggered by the slow moving commutator 24. Accordingly, a high magnitude, unbalanced voltage is generated in the pen motor drive circuit 60, causing the pen 37 to move almost entirely across the graph paper 24, while the graph paper 24 moves longitudinally only slightly, as clearly illustrated by the line portion 62, to designate hard rock.

In the event that it is desired to raise the drill rod 13 for inspection of the hole 75 (FIG. 1), the opposing clutch teeth of the unidirectional drive discs 20 and 21 disengage so that the drum 23 will not be driven in reverse. In other words, the unidirectional clutch discs 20 and 21 permit driving of the drum 23 only in the for-

ward direction of the arrow disclosed in FIG. 1. Simultaneously, the disengaged contacts 40 and 41 de-energize the coil 39 in the position indicator circuit 67, thereby permitting the pen 37 to be lifted to an inoperative position disengaging the paper 24. When the drill rod 13 is lowered to its original position before retraction, the clutch teeth of the unidirectional drive discs 20 and 21 are in position for driving, reclosing the contacts 40 and 41 to lower the pen 37 so that the pen 37 and the paper 24 are ready to resume their recording operation in the same position as they were before the drill rod 13 was raised.

When it is desired to raise the drill rod 13 for replacement, or for adding a rod extension to the drill rod, the stop button 69 is depressed to de-energize the coil 17' of the electromagnetic clutch 17 so that neither the commutator 44 or the drum 23 are driven until the drill rod 13 and its extension are back in position to resume drilling.

It will be understood that, instead of an accelerometer, the transducer 32 could be a pressure sensor located at the exhaust part of the hammer assembly 12, or a pressure sensor located in the air line of the pneumatic system which drives the hammer assembly.

What is claimed is:

1. In combination with a track drill having a drill rod and a hammer assembly for periodically imparting blows to the drill rod to drive the drill rod into soil, a soil impedance log comprising:

- a. means operatively connected to said track drill to record the depth of penetration of said drill rod into said soil,
- b. a transducer on said track drill for sensing each blow imparted by said hammer assembly to said drill rod and for producing a corresponding electrical input signal,
- c. electrical means for counting the electrical input signals for each predetermined unit of drill rod penetration to produce a corresponding output signal for each said unit,
- d. means responsive to said output signals and cooperating with said recording means to represent the number of blows per unit of penetration at each corresponding depth of penetration of said drill rod.

2. The invention according to claim 1 in which said electrical counting means comprises means for storing said electrical input signals, said stored signals having a voltage magnitude proportional to the number of input signals, electrical trigger means operatively connected to said track drill for converting said stored sig-

nals, at the end of each of said units of penetration, to produce each of said output signals.

3. The invention according to claim 2 in which said electrical counting means further comprises means for converting said input signals into current pulses of equal magnitude for storage.

4. The invention according to claim 2 in which said trigger means comprises a rotary commutator switch operatively connected to said drill rod for proportional movement with said drill rod, said commutator switch having at least two uniformly spaced electrical contacts corresponding to said unit of penetration.

5. The invention according to claim 2 in which said recording means comprises means for visually indicating said depth of penetration, and said cooperating means comprises means for visually representing the number of blows per unit of penetration simultaneously with the visual indication of said depth of penetration for visual comparison.

6. The invention according to claim 5 in which said recording means further comprises a scribing surface, means for moving said scribing surface in one longitudinal direction a distance proportional to the depth of penetration of said drill rod, a scribing instrument for indicating said depth of penetration on said scribing surface, said cooperating means comprising means for driving said scribing instrument transversely of said scribing surface a distance proportional to the voltage magnitude of each output signal.

7. The invention according to claim 6 in which said recording means further comprises a unidirectional drive means coupling said drill rod to said means for moving said scribing surface, so that said scribing surface moves only in said one longitudinal direction.

8. The invention according to claim 6 further comprising means for disengaging said scribing instrument from said scribing surface while said drill rod is retracted from its penetrating position.

9. The invention according to claim 2 in which said electrical counting means further comprises electrical integrator means, means for transmitting said stored signals to said integrator means, said integrator means integrating said stored signals to produce each output signal having a voltage magnitude proportional to the number of blows per unit of penetration, for actuating said cooperating means.

10. The invention according to claim 1 in which said transducer is mounted on said drill track for sensing the vibrations of each of said blows.

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