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(54) **DOWNHOLE SAMPLING METHOD AND DEVICE USED IN STANDARD PENETRATION TEST**

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(57) **ABSTRACT**

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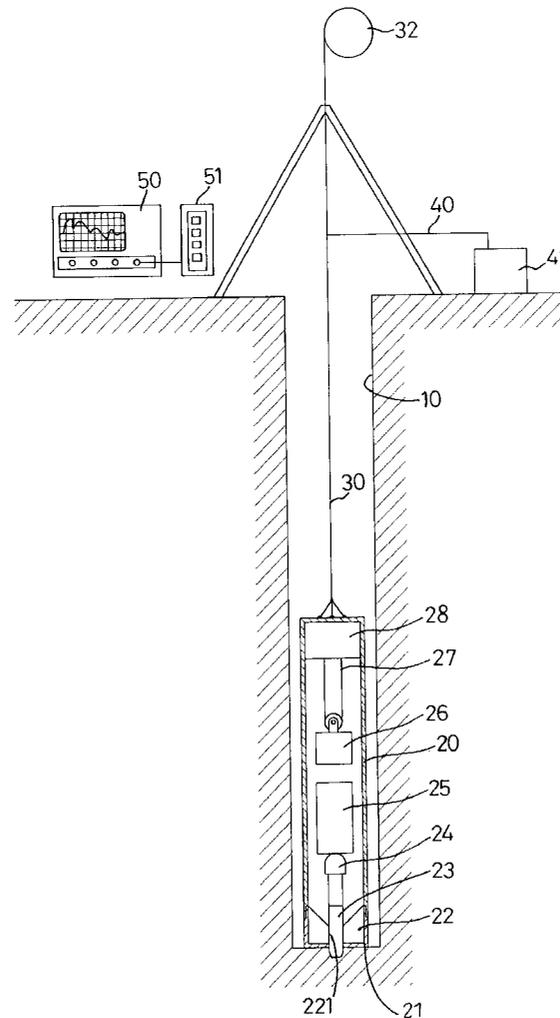
A sampling device has a closed housing, a split-barrel sampler, an anvil, a drop hammer and a lifting device. The split-barrel sampler is mounted in and extends out from the bottom end of the housing. The anvil is attached to the top of the split barrel sampler. The drop hammer is moveably mounted in the housing and is located above the anvil. The lifting device is mounted in the top end of the closed housing to lift the drop hammer to a specific height above the top of the anvil. With the sampling device, the impact energy generated by the hammer is directly transmitted to the sampler through the anvil. The impact energy lost is minimized, and the accuracy of the Standard Penetration Test result is improved.

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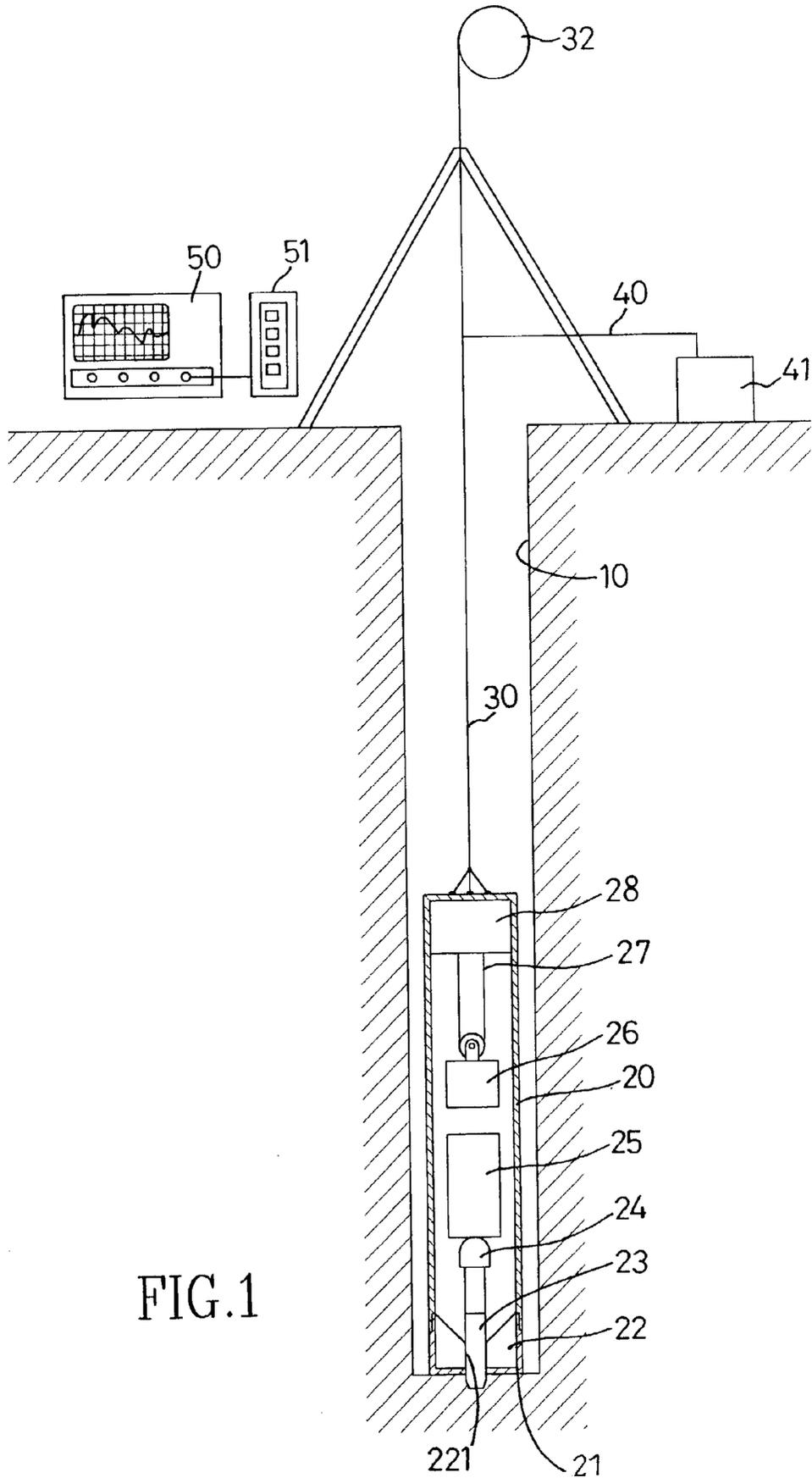


FIG.1

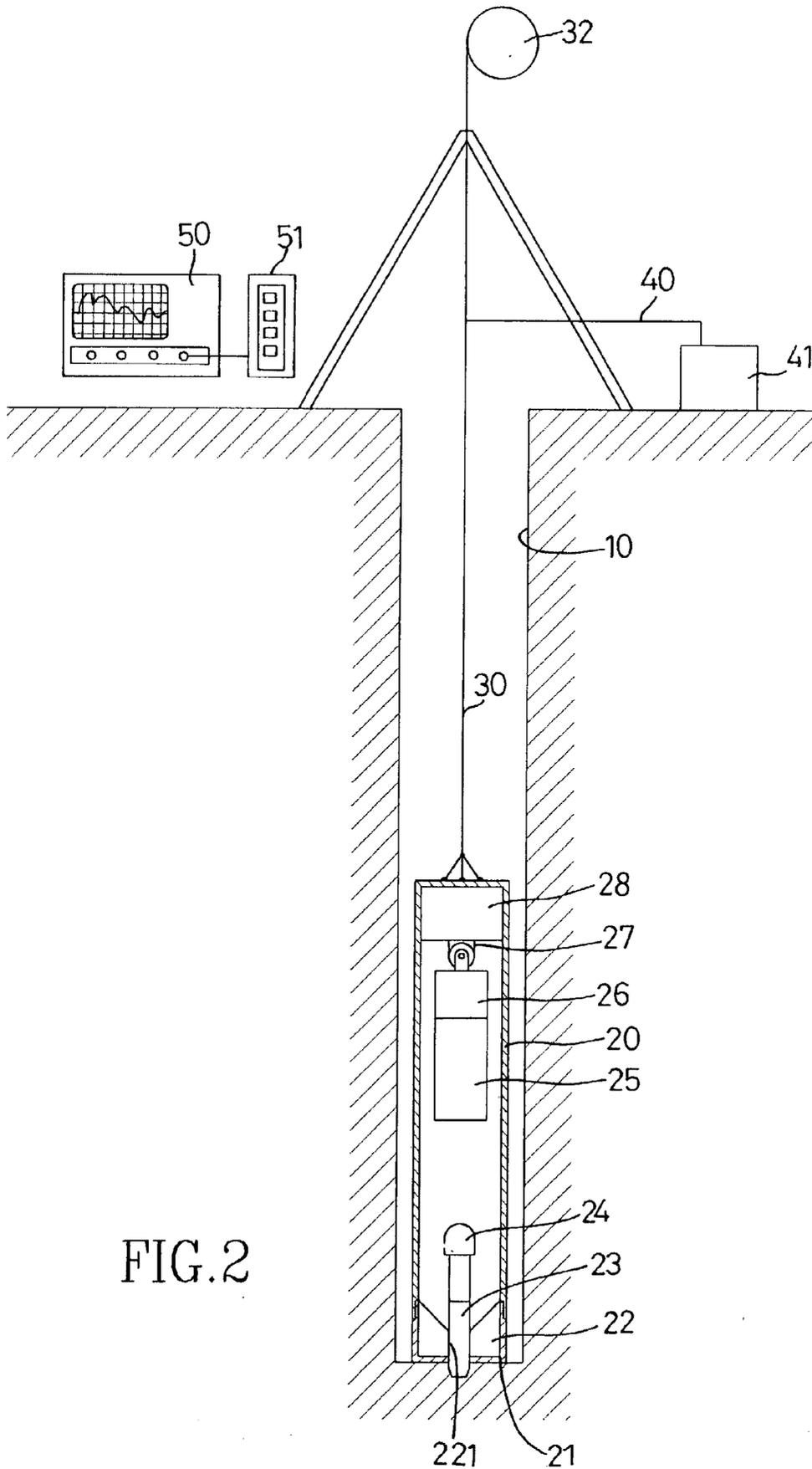


FIG. 2

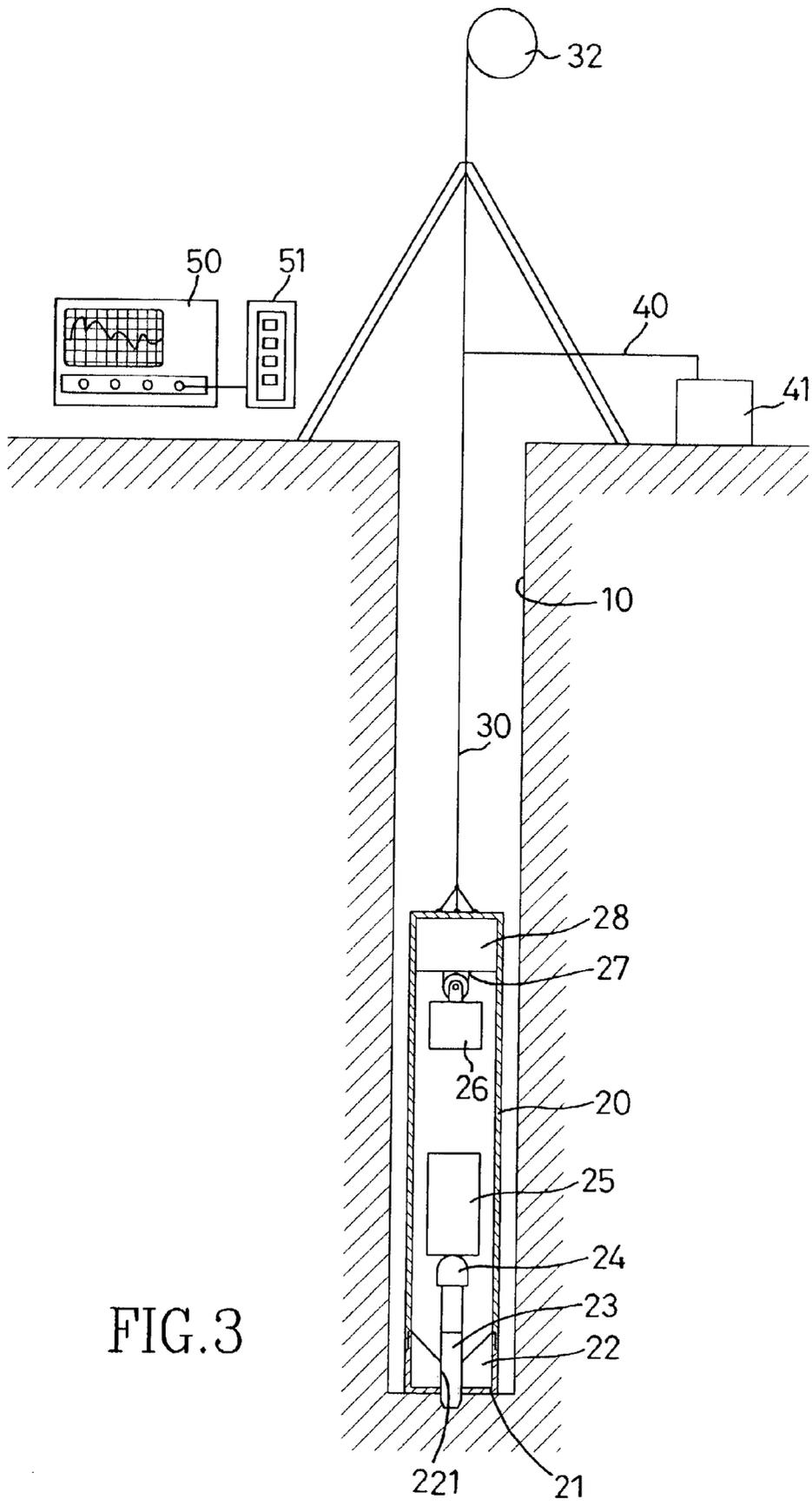


FIG. 3

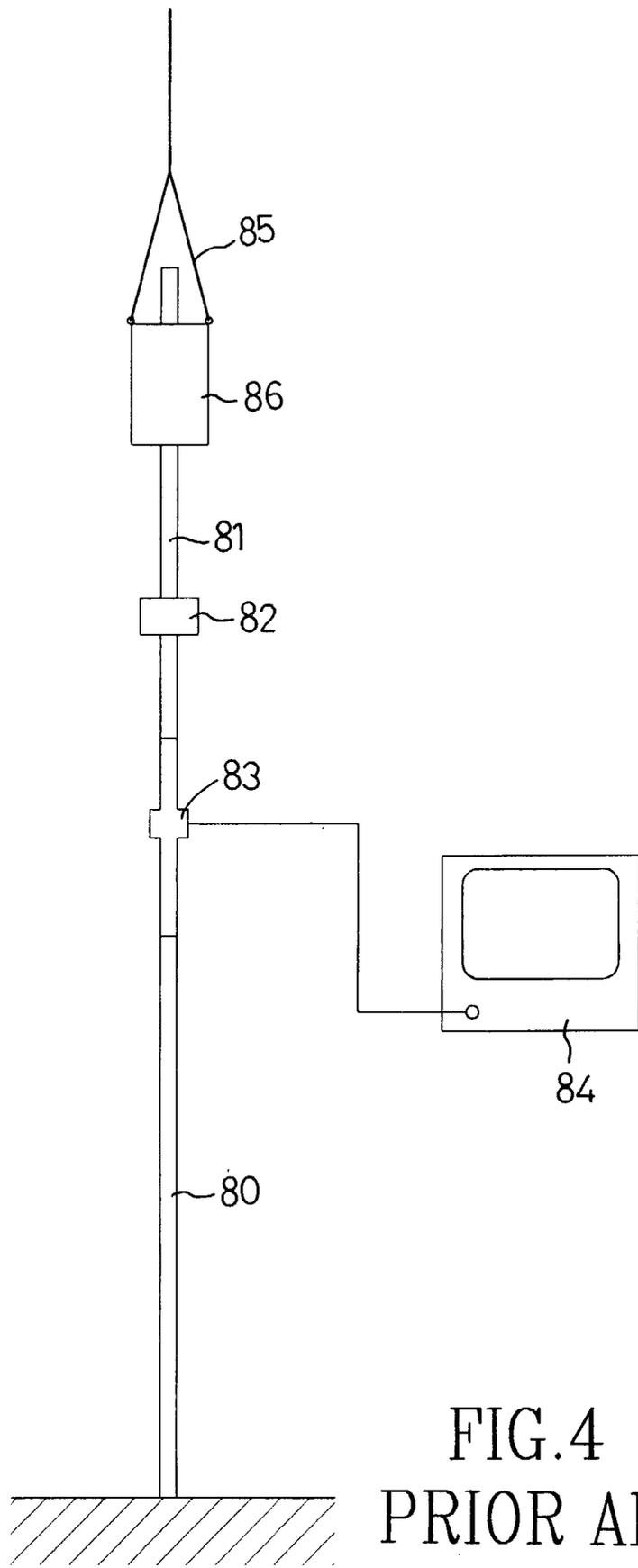


FIG. 4
PRIOR ART

DOWNHOLE SAMPLING METHOD AND DEVICE USED IN STANDARD PENETRATION TEST

BACKGROUND OF THE INVENTION

[0001] 1. Field of the Invention

[0002] The present invention relates to an impact method and a sampling device, and more particularly to an impact method and a device used in Standard Penetration Test (SPT), which can enhance the impact energy by reducing the energy lost during testing.

[0003] 2. Description of Related Art

[0004] Construction engineers in the United States commonly use the Standard Penetration Test (SPT) as a routine prerequisite in subsurface investigations for foundation design. As a common practice, the foundation design is normally accomplished on the basis of the SPT results (the N-value). The American Society for Testing and Materials (ASTM) provides Standard Method (D1586-99) entitled, "Standard Test Method for Penetration Test and Split-Barrel Sampling of Soils" for performing the SPT. The ASTM Standard Method defines the SPT test for most engineering users.

[0005] The Standard Penetration Test (SPT) consists of driving a split-barrel sampling "spoon" or sampler a distance of 30 cm (12 in) into the ground after first "seating" the sampler 15 cm (6 in) by dropping a 63.5 kg (140 lb) hammer from a height of 76 cm (30 in). In field practice, the sampler is driven to a designated depth through a borehole using a long rod, and the hammer strikes the top end of the rod above the ground surface. The operator counts the number of blows that it takes to advance the sampler each of three 15 cm (6 in) increments. When the sampler has penetrated 45 cm (18 in) into the soil at the bottom of the borehole, the operator adds the number of blows for the second and third increments. This combined number is the result of the SPT and is called the "blow count" and is customarily designated as "N" or the "N value". It directly reflects the penetration resistance of the ground or the soil under investigation.

[0006] The SPT is used as the primary soil descriptor in a geotechnical engineering (or foundation engineering) analysis and design. In most practices, the SPT is used in conjunction with other laboratory and field-testing procedures and serves as an indicator of the soil profile. The SPT has been correlated with the soil's capacity to resist ground failure or excessive settlement once a new building is erected. Therefore, the N-values obtained on a specific site are very important criteria for engineers to evaluate the stability and the possible settlement of new buildings to be constructed. From a logical perspective, engineers have a basic understanding that dense soil or solid ground should have a higher N value because of a higher penetration resistance. Previous experience has correlated the ground conditions of some soil types, such as sand and clay, to certain N values.

[0007] Previous studies have shown that the N value is closely related to the energy delivered to the rod by the hammer impact. In consequence, any significant variation in the energy transmitted to the rod from the hammer can have a dramatic effect on the N value. For example, when the pounding effect or the energy transfer between the hammer and the rod is poor and the energy delivered to the rod is

lower than what is expected, the resulting N value will be higher than it should be. This will seriously bias the engineer's judgment and lead to a faulty conclusion with regard to the subsequent design and construction. Due to the described shortcoming, an improved method with a specific device is thus proposed here to provide an effective impact technique to transmit consistent energy.

[0008] With the reference to FIG. 4, conventional equipment used to perform the SPT comprises a rod (80), an anvil (82), a sampler (not shown) and a drop hammer (86). The anvil (82) is securely mounted on the top of the rod (80), and the sampler (not shown) is attached to the bottom of the rod (80). The drop hammer (86) is located above the anvil (82). To carry out the SPT, the hammer (86) is lifted to a height of 30 in (76 cm) above the anvil (82) by a lifting device (85), and the hammer (86) is supposed to "free-fall" drop to impact the anvil (82). The induced impact energy will then transmit through the rod (80) and down to the sampler. To ensure the movement of the hammer (86) is straight, a guide post (81) is mounted on top of the anvil (82) and passes through a hole (not shown) in the drop hammer (86) to make the hammer (86) slide along the guide post (81). In this procedure, the stress wave of the impact can be measured by a sensor (83) attached to the rod (80) with the signal received by the sensor (83) transmitted to a computer (84) near by. The impact energy transferred is then calculated by the computer (84).

[0009] When the conventional equipment is used underground or underwater, at least one auxiliary rod must be attached to the rod (80) to put the sampler at the designated depth below the surface. The auxiliary rods are mounted between the rod (80) and the anvil (82) with fastening screw joints, such that the impact energy generated by the hammer (86) is transmitted to the sampler through the anvil (82), the auxiliary rods and the rod (80). However, when the length or quantity of the auxiliary rods increases, a portion of the impact energy generated from the hammer (86) will be lost, and thus less energy transmitted to the sampler. If any of the joints between the auxiliary rods or between an auxiliary rod and the anvil (82) or the rod (80) is loose or even one of the auxiliary rods is bent, the energy lost will be greater. Based on previous experience and test results, only approximately 40-90% of the ideal impact energy (475 joules) is transmitted to the sampler. In addition, the diameter, the length and the straightness of each auxiliary rod are importance factors in the transmission of the impact energy generated by the hammer (86) to the sampler. In an experiment using the conventional testing equipment with the rod (80) and the auxiliary rods being 11.7 meter (m) in length, the energy near the anvil (82) was 63% of the ideal impact energy generated by the hammer (86). The transmitted energy was further reduced to 27.8% of the impact energy near the sampler. The energy lost between the anvil (82) and the sampler was about 25.2%. In another experiment using the conventional testing equipment with the rod (80) with the auxiliary rods being 22.7 m in length, the energy lost between the anvil (82) and the sampler was about 41.0%. As shown in the foregoing experiments, the energy lost increases when the length of the rod (80) with the auxiliary rods increases.

[0010] To overcome the shortcomings, the present invention tends to provide an impact method and a sampling

device used in Standard Penetration Test (SPT) to mitigate or obviate the aforementioned problems.

SUMMARY OF THE INVENTION

[0011] The main objective of the invention is to provide an impact method and a sampling device used in Standard Penetration Test (SPT) to reduce the loss of the impact energy transmitted to the sampler. The sampling device has a closed housing, a split-barrel sampler, an anvil, a drop hammer and a lifting device. The split-barrel sampler is mounted on and extends out from the bottom end of the housing. The anvil is attached to the top of the split barrel sampler. The drop hammer is moveably received in the housing and is located above the anvil. The lifting device is mounted on the top end of the closed housing to lift the drop hammer to a specific height above the top of the anvil.

[0012] The impact method comprises the steps of drilling a hole in the ground, setting a sampling device into the hole, lifting the hammer to a height of 76 cm (centimeters) above the top of the anvil and free falling the hammer to impact the anvil. With the impact method and the sampling device, the impact energy generated by the hammer is directly transmitted to the sampler through the anvil even when the sampling device is underground. Consequently, the loss of the impact energy is minimized, and the Standard Penetration Test is improved.

[0013] Other objects, advantages and novel features of the invention will become more apparent from the following detailed description when taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0014] FIG. 1 is an operational side plan view in partial section of a Standard Penetration Test (SPT) sampling device in accordance with the present;

[0015] FIG. 2 is an operational side plan view in partial section of the sampling device in FIG. 1 with the hammer lifted above the anvil by the lifting device;

[0016] FIG. 3 is an operational side plan view in partial section of the sampling device in FIG. 1 as the hammer free falls and impacts the anvil; and

[0017] FIG. 4 is an operational side plan view of a conventional Standard Penetration Test (SPT) sampling device in accordance with the prior art.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENT

[0018] With reference to FIG. 1, a Standard Penetration Test (SPT) sampling device in accordance with the present invention comprises a closed housing (20), a split-barrel sampler (23), an anvil (24), a drop hammer (25) and a lifting device. The closed housing (20) has a top end and a bottom end. In practice, the top end of the housing (20) is a closed end, and the bottom end of the housing (20) is an open end. An inner thread is defined in the open end of the housing (20). A bottom cover (21) with threads is screwed into the inner thread in the bottom end of the closed housing (20) to close the bottom end of the closed housing (20). A support base (22) is formed in the bottom cover (21) and has a through hole (221) defined through the supporting base (22).

[0019] The split-barrel sampler (23) is mounted on the bottom end of the housing (20) and extends out from the through hole (221) in the bottom cover (21). The anvil (24) is attached to the top of the split barrel sampler (23). The drop hammer (25) is moveably mounted in the housing (20) and is located above the anvil (24). The lifting device is mounted in the top end of the housing (20) to lift the drop hammer (25) to a specific height above the top of the anvil (24). The lifting device comprises a driving device (28) and a lifting element (26). The driving device (28) is attached to the top end of the closed housing (20). In practice, the driving device (28) can be a motor with a cable wheel attached to the shaft of the motor. The lifting element (26) is connected to the driving device (28) by a connecting cable (27) and corresponds to the drop hammer (25) to hold and to lift the drop hammer (25). In practice, the lifting element (26) is an electromagnet. One end of the connecting cable (27) is secured to the motor, and the other end of the cable (27) is securely attached to and mounted around the cable wheel. When the motor is switched on, the cable wheel will rotate with the shaft of the motor. Consequently, the cable (27) will be reeled onto or off of the cable wheel so that the lifting element (26) will move up or down.

[0020] With reference to FIGS. 1 to 3, the SPT is performed by first drilling a hole (10) in the ground with a bottom at a designated depth. Then, the sampling device is set at the bottom of the hole (10). The sampler (23) penetrates through the bottom of the housing (20) and abuts the bottom of the hole (10). To set the sampling device in the hole (20) with a designated depth, a cable (30) with a top and bottom end is connected to the housing (20) at the bottom end of the cable (30) and is connected to a crane (32) at the top end of the cable (30). The crane (32) and the cable (30) lower the sampling device into or remove it from the hole (10).

[0021] The driving device (28) lowers the lifting element (26) until it comes in contact with the hammer (25). The lifting element (26) is magnetized to securely attach the hammer (25) to the lifting element (26). When the lifting element (26) is moved up in the housing (10) by the driving device (28) and the connecting cable (27), the hammer (25) will move with the lifting element (26). When the drop hammer (25) is moved to a height of 76 cm (centimeters) above the top of the anvil (24), the electromagnetism of the lifting element (26) is turned off so the drop hammer (25) will free fall and impact the anvil (24). Because the anvil (24) is attached to the sampler (23), the impact energy generated by the hammer (25) is directly transmitted to the sampler (23). Any impact energy lost is minimized so that the results of the SPT are more accurate than those of the SPT applied with the conventional sampling device. With the sampling device and the impact method, the sampling device can be used underground or underwater without any auxiliary rods, such that the use of the sampling device is versatile.

[0022] The pressure in the housing (20) is maintained by an air pipe (40) and a pressure balance device (41). The air pipe (40) has two ends. One end is connected to the housing (20), and the other end is connected to the pressure balance

device (41). Accordingly, the pressure in the housing (20) is controlled to be the same as that in the outer environment when the housing has to be submerged below ground water level. This prevents the results of the SPT from being influenced by the possible water pressure in the housing (20).

[0023] A wireless sensor (not shown) is mounted on the anvil (24) to detect and transmit the impact energy applied by the hammer (25) to a receiver (51). The receiver (51) is arranged to receive impact energy signals sent out from the sensor. An oscilloscope (50) is electrically connected to the receiver (51) to display the impact energy. Consequently, the operator can monitor the operation of the sampling device with the sensor, the receiver (51) and the oscilloscope (50).

[0024] Since the hammer (25) strikes the anvil (24) on a specific contact surfaces, the contact surfaces of the anvil (24) and the hammer (25) can be designed to round or flat. A round contact surface on either the anvil (24) or the hammer (25) results in a single point-contact impact between the hammer (25) and the anvil (24), which improves the energy transfer efficiency of the sampling device and the accuracy of the SPT results.

[0025] Even though numerous characteristics and advantages of the present invention have been set forth in the foregoing description, together with details of the structure and function of the invention, the disclosure is illustrative only, and changes may be made in detail, especially in matters of shape, size, and arrangement of parts within the principles of the invention to the full extent indicated by the broad general meaning of the terms in which the appended claims are expressed.

What is claimed is:

1. A sampling device used in a Standard Penetration Test comprising:

- a closed housing having a top end and a bottom end;
- a split-barrel sampler with a top end and a bottom end mounted in and extending out from the bottom end of the housing;
- an anvil attached to the top end of the split barrel sampler;
- a drop hammer moveably mounted in the housing and located above the anvil;
- a lifting device mounted in the top end of the closed housing to lift the drop hammer to a specific height above the top of the anvil.

2. The sampling device as claimed in claim 1, wherein the bottom end of the closed housing is an opening end with inner thread; and

a bottom cover with thread is screwed to the inner thread in the bottom end of the closed housing to close the bottom end of the closed housing,

wherein the bottom cover has a supporting base with a through hole for the split-barrel sampler penetrating through the through hole.

3. The sampling device as claimed in claim 1, wherein the anvil has a round top face to serve as a contact face with the drop hammer.

4. The sampling device as claimed in claim 3, wherein the drop hammer has a round bottom face to serve as a contact face with the anvil.

5. The sampling device as claimed in claim 3, wherein the drop hammer has a flat bottom face to serve as a contact face with the anvil.

6. The sampling device as claimed in claim 1, wherein the anvil has a flat top face to serve as a contact face with the drop hammer.

7. The sampling device as claimed in claim 6, wherein the drop hammer has a round bottom face to serve as a contact face with the anvil.

8. The sampling device as claimed in claim 6, wherein the drop hammer has a flat bottom face to serve as a contact face with the anvil.

9. The sampling device as claimed in claim 1, wherein the lifting device comprises:

a driving device mounted in the top end of the closed housing; and

a lifting element connected to the driving device with a connecting cable and corresponding to the drop hammer to hold and lift the drop hammer.

10. The sampling device as claimed in claim 9, wherein the lifting element is an electromagnet.

11. A method of using a sampling device for a Standard Penetration Test as claimed in claim 1, the method comprising acts of:

drilling a hole in a sample of ground where the hole has a bottom at a designated depth;

setting a sampling device at the bottom of the hole;

lifting a hammer to a height of 76 cm (centimeters) above a top of an anvil with a lifting device; and free falling the hammer to impact the anvil.

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