April 11, 1967 A. A. VENGHIATTIS 3,313,357

UNDERWATER SAMPLING APPARATUS

Filed Nov. 23, 1964 2 Sheets-Sheet 1

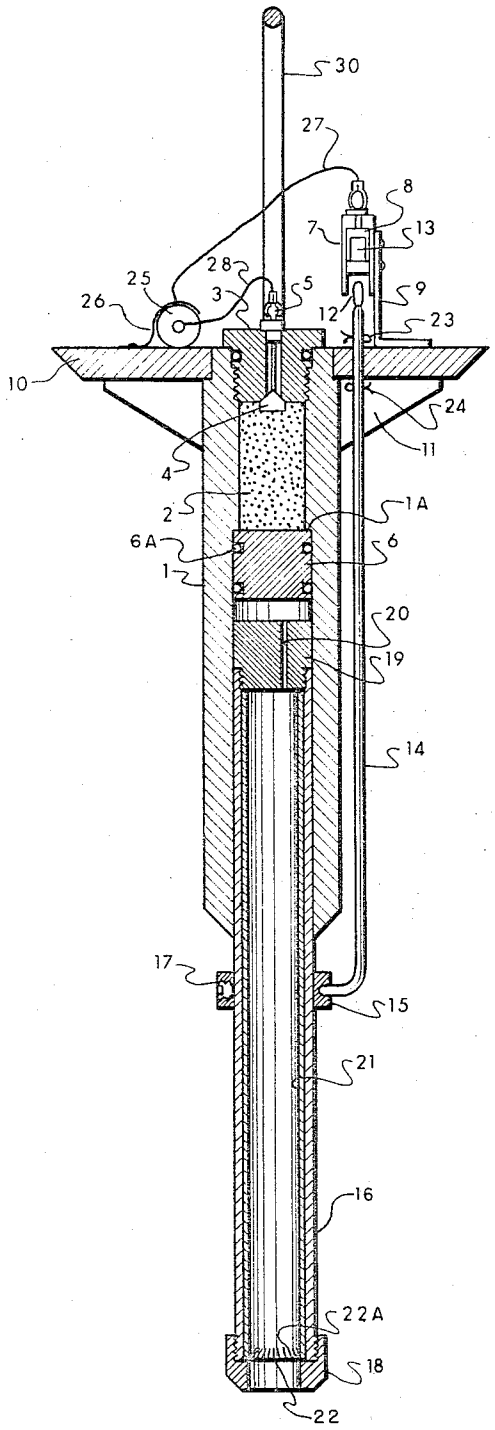

FIG. 1

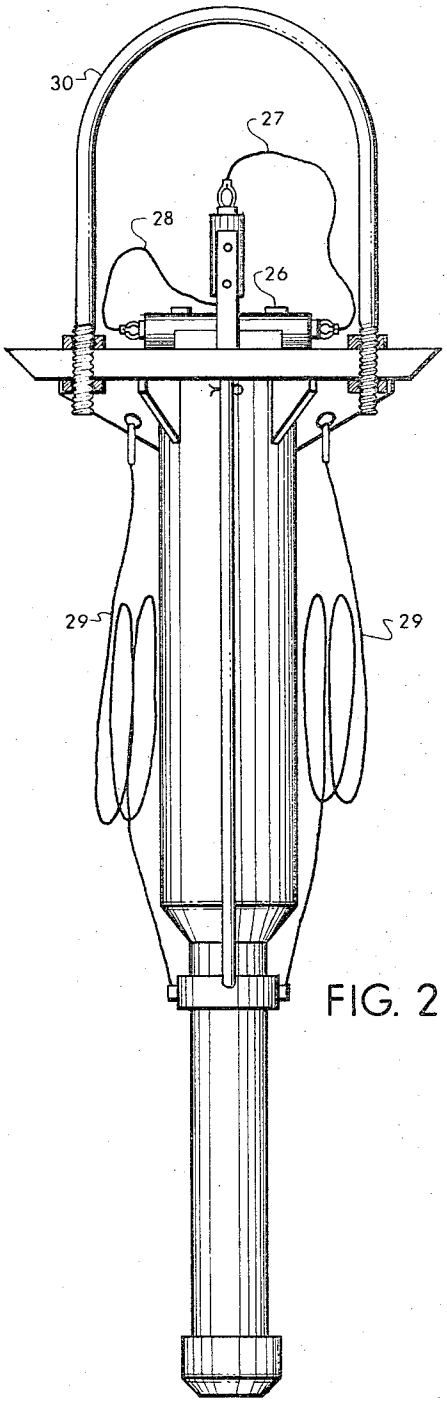

FIG. 2

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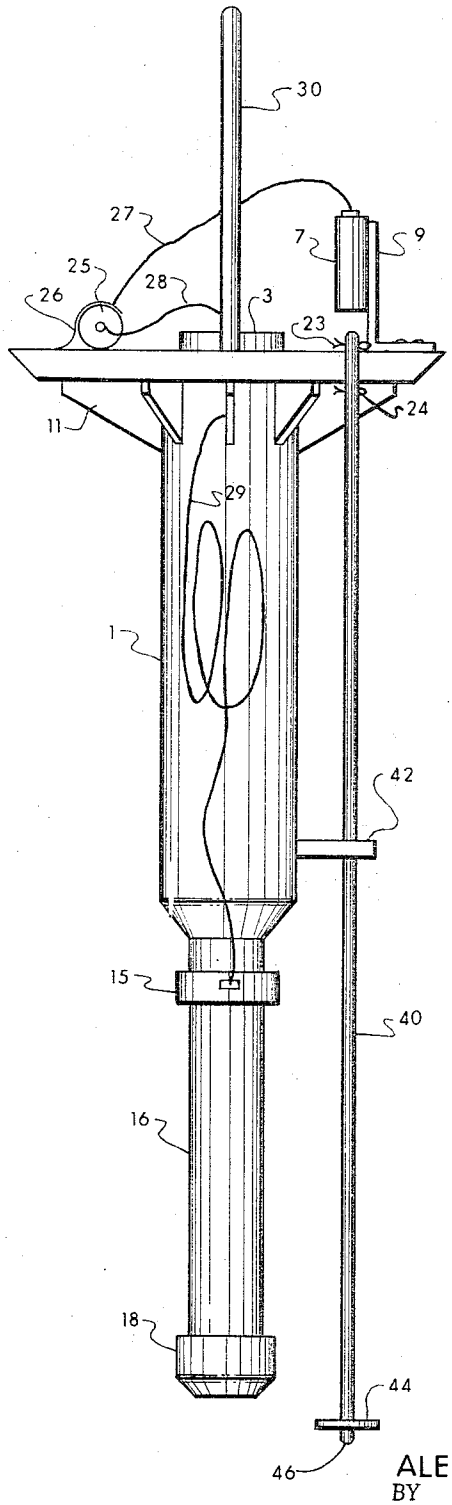

FIG. 3

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UNDERWATER SAMPLING APPARATUS

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17 Claims. (Cl. 175—6)

This invention relates to apparatus for obtaining earth samples from remote locations, and more particularly relates to apparatus for obtaining earth samples from submerged lands such as ocean, lake, and river beds.

There are many occasions when it is desirable to know the character of the substances or strata which happen to be submerged by water. This is particularly true in the case of oceanographic investigations, where it is sought to obtain samples of the ocean bottom to determine the geographic history of the earth. Such samples are most useful, however, when they can be obtained in a relatively undisturbed condition since the character and thickness of the layers is often of great interest.

It is often possible, in shallow lakes and rivers, to obtain relatively undisturbed samples by simple coring methods such as hand-driving, or gravity driving, a long tube or auger into the river or lake bed.

Such methods and techniques are impractical for most investigations of a primarily scientific purpose, and are completely impossible in the case of most ocean depths. Consequently, most of the samples obtained at relatively great depths have been taken by dredging techniques, and this results in comingling of the various layers of such samples. Accordingly, there has long been a need for some simple method or apparatus which could be used to inexpensively obtain an undisturbed or unmixed core from a deep lake or ocean bed. Until the present invention was made, however, no such simple and inexpensive method or apparatus has been available.

These disadvantages of the prior art are overcome by the use of the present invention which, in its preferred form, includes an explosively-operated coring device which is adapted to be lowered into the water by means of a simple cable, and which is actuated by contact with the ocean or lake bed. In particular, a gun is provided which includes an explosively-dischargeable coring barrel, and which is adapted to be lowered through the water in a muzzle-down position. When the muzzle of the coring barrel contacts the bed, the coring barrel is pushed back into the apparatus to actuate the explosive charge. Actuation of the charge drives the coring barrel out of the gun and into the ocean bed. The coring barrel remains connected to the gun by flexible cables, and thus when the gun is lifted to the surface the cables will carry the coring barrel with it.

Accordingly, it is an object of the present invention to provide apparatus for obtaining relatively un-comingled earth samples from remote locations which are substantially true cross sectional representations of the earth strata at such locations.

It is also an object of the present invention to provide cable-supported apparatus for driving a hollow tubular member into remote water-covered earth substances including means for retrieving said member from said substances.

It is further an object of the present invention to provide cable-supported apparatus for driving a hollow tubular member into remote water-covered earth substances upon contact therewith and including means for thereafter retrieving said member from said substances.

These and other objects of the present invention will be apparent from the following detailed description wherein reference is made to the figures in the accompanying drawings.

In the drawings:

FIGURE 1 is a cross sectional representation of a preferred form of the present invention.

FIGURE 2 is a pictorial representation of the apparatus shown in FIGURE 1, but viewed from a point 90 degrees in rotation

FIGURE 3 is a pictorial representation of another form of the present invention.

Referring to FIGURES 1 and 2, there may be seen apparatus presented in its normal position for taking an earth sample, including a steel gun body **1** containing in its upper end section a propelling charge **2** of suitable explosive, and having a steel breech plug **3** threadably inserted in the upper end of the body **1**. The upper end of the propelling charge **2** is preferably fitted with an electrically actuated igniter **4** which is suitably connected to an electrical connector or junction **5** extending through the breech plug **3**. The junction **5** should not only be electrically insulated from the steel plug **3**, but should also provide a water-tight seal against entry of water to the igniter **4** and propelling charge **2**. Inside the body **1**, and adjacent the lower surface of the propelling charge **2**, is a piston **6** having ring gaskets **6A** for providing a water-tight and gas-tight seal for the propelling charge **2**.

Also mounted on the upper end of the gun body **1** is a steel recoil brake **10** which is formed in the manner of a horizontal and circular plate or platform, and which is supported by a plurality of steel ribs **11** or buttresses arranged equidistantly about the outside surface of the upper end portion of the body **1**. A triggering box **7** is supported above the upper surface of the brake by a bracket **9**. The triggering box **7** is formed of stainless steel and has an opening or aperture in its bottom end. A suitably insulated electrical socket **8** is disposed inside the bottom end of the triggering box **7** which is also filled to capacity with a thick water-repellent grease of suitable character to prevent any entry of water into the triggering box **7** when the apparatus is submerged.

The lower end of the gun body **1** contains a sampler projectile **16**, which is a hollow open-ended tube, and which is slideably disposed in the gun body **1** in a substantially fluid-tight manner so as to extend out of the bottom thereof. The upper end of the projectile **16** is threadably fitted with a metal plug **19** having a small-diameter hole **20** therethrough. The lower end of the projectile **16** is threadably fitted with a ferrule-like cap **18** for impact protection. This cap **18** also functions to position at the lower end of the projectile **16** a retainer **22** having a plurality of flexible fingers **22**–A extending upwardly into the projectile **16**.

Inside the projectile **16** there may also be found a thin metallic sleeve **21** or liner extending between the plug **19** and the retainer **22**. This sleeve **21**, which is snugly but not immovably fitted into the projectile **16**, is preferably pre-cut into two longitudinal halves for reasons which will hereinafter be apparent. A ring or collar **15** is adjustably fixed to the outer surface of the projectile **16** by a set screw **17**, or other suitable fastening means, at a preselected location along the length of the projectile **16**. This collar **15** functions to support a relatively rigid rod **14** which extends upwardly in a parallel relationship with the projectile **16**, through an aperture in the recoil brake **10**, to the lower open end of the triggering box **7**. The upper end of the rod **14** is provided with a plug **12**, which is adapted to be inserted into the electrical socket **8** to close the ignition circuit as will hereinafter be explained.

Also supported on the recoil brake **10** by a bracket **26** is a water proof battery box **25** containing a suitable source of electrical power (such as batteries), with one terminal connected to a conductor **28** leading to the junction **5**, and with the other terminal connected to a conductor **27** lead-

ing to the socket 8. The junction 5 is connected electrically to the igniter 4 which, in turn, is electrically connected to conduct current between the batteries in the battery box 25 and "ground" (which is the steel in the gun body 1 and the recoil brake 10).

As hereinbefore stated, the socket 8 is electrically insulated by a gap filled with grease in the triggering box 7. A thin sheet or membrane of rubber (not shown) may also be interposed inside the triggering box 7, between the socket 8 and the open lower end of the triggering box 7, to keep out water. However, when the apparatus reaches the floor of the ocean or lake, and the cap 18 butts against resistant substances, the projectile 16 and rod 14 will halt but the gun body 1 and other portions of the apparatus will continue to descend until the plug 12 punctures the rubber membrane (if any) in the triggering box 7, and pushes through the grease into the socket 8. The metallic rod 14 is electrically connected to the gun body 1. Accordingly, the ignition circuit is now completed and the propelling charge 2 is ignited to explode the projectile 16 down into the ocean floor.

It will be apparent that the gun body 1 and projectile 16 should be as nearly vertical as possible, when the propelling charge 2 explodes. The apparatus is provided with bail 30, which is threadably connected to the recoil brake 10, and to which a suitable cable, chain, or flexible line may be connected to lower the apparatus into the water. Accordingly, it is desirable that the apparatus be "bottom-heavy" so that it will hang as nearly vertical as possible—even though a relatively strong horizontal current may be present. This is achieved by having the center of gravity of the apparatus located located well below the point of suspension of the gun (point of attachment of the cable and bail 30).

It is desirable that the gun body 1 be rendered longitudinally movable only a preselected distance or spacing with respect to the projectile 16. This is because the rod 14 is fixedly attached to the projectile 16, and it is necessary that the plug 12 not be permitted to damage the socket 8. Accordingly, the rod 14 must be connected to the projectile 16 at a point such that, when the plug 19 contacts the piston 6 the plug 12 on the end of the rod 14 is properly seated in the socket 8. The preselected spacing should also be such as to permit the gun to be "fired" before it tilts substantially from vertical.

When the propelling charge 2 explodes, the piston 6 which traps the expanding gases inside the gun body 1 is driven downward to push the projectile 16 out of the gun body 1 and into the ocean floor. As is well known in ballistics, the gun body 1 is driven upwards as the projectile 16 is driven downward into the ocean floor. This recoil is resisted or overcome by the recoil brake 10 which offers a great resistance against acceleration in the water above it.

It should be noted that the inside diameter, of that portion of the gun body which is occupied by the propelling charge 2, is preferably slightly smaller than those portions occupied by the projectile 16, plug 19, and piston 6. This provides a shoulder 1A to prevent the piston 6 from crushing the propelling charge 2 under the effect of the underwater pressure.

After the propelling charge 2 has been exploded, and after the projectile 16 has been driven into the ocean or lake bed, it is necessary to recover the projectile 16. Accordingly, the projectile 16 is connected to the gun body 1 by means of at least a pair of flexible cables 29, which are linked between the collar 15 and the ribs 11, and which function to drag the projectile up with the gun body 1 when the apparatus is lifted to the surface.

When the projectile 16 plunges into the ocean floor, it will tend to punch out a "core" of the substances, and the upwardly-directed, spring-like fingers on the retainer 22 will bend back to admit the core into the liner 21, and water in the projectile will be displaced out through the aperture 20 in the plug 19. If the core is composed of an unconsolidated substance such as mud, the fingers on the retainer 22 will tend to hold the core in place in the liner 21 after the projectile 16 is pulled out of the ocean floor. A relatively consolidated core sample will, of course, remain in the projectile 16 without any need for the retainer 22.

After the projectile 16 has been lifted to the surface, the core should be removed without disturbing or mixing it any more than is absolutely necessary. The cap 18, retainer 22, and plug 20 is therefore removed, and pressure is applied to the edges of the liner 21 to drive it out of the projectile 16. After the pre-cut liner 21 has been ejected, the two halves thereof may be easily removed without damage to the core.

The ignition circuit of the apparatus may, if desired, be made responsive to actuation from the surface by any conventional means, such as by an electric signal which may pass down through an insulated conductor in the cable attached to the bail 30. However, this is not desirable unless means are also provided to indicate the instant when the apparatus touches the ocean bottom. Otherwise, the gun would be in danger to be fired when lying on the bottom, or before reaching the bottom. Accordingly, it is preferable to make the ignition circuit responsive to contact with the ocean floor by the lower end of the projectile 16.

Accidental discharge of the apparatus depicted in FIGURES 1 and 2 is prevented by pins 23 and 24, which are located on opposite sides of the recoil brake 10 to prevent unwanted movement of the rod 14. However, pin 24, which is located next to the underneath side of the recoil brake 10, is strong enough merely to resist accidental bumping of the projectile 16, and is adapted to break or shear under the weight of the gun body 1 and associated portions of the apparatus when the projectile 16 comes to rest on the ocean floor.

Referring now to FIGURE 3, there may be seen an alternative form of the apparatus depicted in FIGURES 1 and 2, wherein the actuating rod 40 is slideably located in a bracket 42 mounted on the gun body 1, and has a plate 44 of preselected diameter or surface area threadably mounted on its lower end. In this form of the present invention, it is the plate 44 which first encounters the ocean floor, rather than the lower end of the projectile 16 as is the case with the apparatus depicted in FIGURES 1 and 2. Thus, the apparatus may be rendered responsive to only ocean floor substances of a minimum consolidation by selected plate 44 of suitable diameter. In other words, if no plate 44 at all is used, the relatively sharp end 46 of the rod 40 will punch down into loosely consolidated substances, such as mud, without causing the lower pin 24 to shear. On the other hand, a plate 44 of relatively large diameter or surface area will not push down through mud, but will cause the pin 24 to shear so that the rod 40 will explode the propelling charge (not depicted).

Numerous other modifications and variations may obviously be made without departing from the concept of the present invention. According, it should be clearly understood that those forms of the present invention which are described herein and depicted in the accompanying drawings, are illustrative only, and are not intended to limit the scope of the invention.

What is claimed is:

1. Apparatus for taking a sample of submerged earth substances, said apparatus comprising

a gun body having a bore and a firing chamber,

a breech plug threadably engaged with said gun body adjacent said firing chamber,

a propelling charge of explosive disposed in said firing chamber,

a tubular projectile slideably disposed in said bore with one open end disposed in said bore adjacent said firing chamber and with the other open end extending out of said bore,

a plug means threadably engaging and closing said one open end of said projectile in said bore and having an aperture,

retainer means fixed to said other open end of said projectile and having a plurality of inwardly and upwardly directed flexible finger-like extensions,

a plate means adapted and arranged about said gun body to hydrostatically resist recoil of said gun body upon ignition of said propelling charge,

an electrical power supply mounted on said plate means,

an electrical socket means mounted on said plate means and connected to said power supply,

an electrically-actuated igniter means disposed in said breech plug in close proximity to said propelling charge and also connected to said power supply,

a switching means responsive to the weight of said gun body and other parts of said apparatus and adapted to enter said socket means to pass power from said power supply through said igniter means,

linking means interconnecting said projectile and said gun body, and

handle means interconnected with said plate means for vertically supporting said gun body.

2. Apparatus for taking a sample of submerged earth substances, said apparatus comprising

a gun body having a bore of a first diameter and a firing chamber of a second smaller diameter,

a breech plug threadably engaged with said gun body adjacent said firing chamber,

a propelling charge of explosive disposed in said firing chamber,

a piston slideably and gas-tightly disposed in said bore adjacent said firing chamber and said propelling charge,

a tubular projectile slideably disposed in said bore with one open end disposed in said bore adjacent said piston and with the other open end extending out of said bore,

a plug means threadably engaging and closing said one open end of said projectile in said bore and having an aperture,

a pre-divided sleeve means slideably disposed in said tubular projectile in the manner of a liner,

retainer means fixed to said other open end of said projectile and having a plurality of inwardly and upwardly directed flexible finger-like extensions,

a plate means adapted and arranged about said gun body to hydrostatically resist recoil of said gun body upon ignition of said propelling charge,

an electrical power supply mounted on said plate means,

an electrical socket means mounted on said plate means and connected to said power supply,

an electrically-actuated igniter means disposed in said breech plug in close proximity to said propelling charge and also connected to said power supply,

a switching means responsive to the weight of said gun body and other parts of said apparatus and adapted to enter said socket means to pass power from said power supply through said igniter means,

linking means interconnecting said projectile and said gun body, and

handle means interconnected with said plate means for vertically supporting said gun body.

3. Apparatus for taking a sample of submerged earth substances, said apparatus comprising

a gun body having a bore of a first diameter and a firing chamber of a second smaller diameter,

a breech plug threadably engaged with said gun body adjacent said firing chamber,

a propelling charge of explosive disposed in said firing chamber,

a piston slideably and gas-tightly disposed in said bore adjacent said firing chamber and said propelling charge,

a tubular projectile slideably disposed in said bore with one open end disposed in said bore a preselected distance from said piston and with the other open end extending out of said bore,

a plug means threadably engaging and closing said one open end of said projectile in said bore and having an aperture,

a pre-divided sleeve means slideably disposed in said tubular projectile in the manner of a liner,

retainer means fixed to said other open end of said projectile and having a plurality of inwardly and upwardly directed flexible finger-like extensions,

a plate means adapted and arranged about said gun body and breech plug to hydrostatically resist recoil of said gun body upon ignition of said propelling charge.

an electrical power supply mounted on said plate means,

an electrical socket means mounted on said plate means and connected to said power supply,

an electrically-actuated igniter means disposed in said breech plug in close proximity to said propelling charge and also connected to said power supply,

a switching means connected to said projectile and responsive to the weight of said gun body and other parts of said apparatus and having a pin means adapted to enter said socket means to connect power from said power supply through said igniter means, said pin means being spaced said preselected distance from said socket means,

flexible linking means interconnecting said projectile and said gun body, and

handle means interconnected with said plate means for vertically supporting said gun body.

4. Apparatus for taking a sample of submerged earth substances, said apparatus comprising

a gun body having a bore of a first diameter and a firing chamber of a second smaller diameter,

a breech plug threadably engaged with said gun body adjacent said firing chamber,

a propelling charge of explosive disposed in said firing chamber,

a piston slideably and gas-tightly disposed in said bore adjacent said firing chamber and said propelling charge,

a tubular projectile slideably disposed in said bore with one open end disposed in said bore a preselected distance from said piston and with the other open end extending out of said bore,

a plug means threadably engaging and closing said one open end of said projectile in said bore and having an aperture,

a pre-divided sleeve means slideably disposed in said tubular projectile in the manner of a liner,

retainer means fixed to said other open end of said projectile and having a plurality of inwardly and upwardly directed flexible finger-like extensions,

a plate means adapted and arranged about said gun body and breech plug to hydrostatically resist recoil of said gun body upon ignition of said propelling charge, said plate means having an eccentrically located aperture,

an electrical power supply mounted on said plate means,

an electrical socket means mounted on said plate means above said aperture therein and connected to said power supply,

an electrically-actuated igniter means disposed in said breech plug in close proximity to said propelling charge and also connected to said power supply,

a switching means responsive to the weight of said gun body and other parts of said aparatus, said switching means including a rod connected at one end to said projectile and extending along side said gun body through said aperture in said plate means, said rod further supporting a pin spaced said preselected dis-

tance from and adapted to enter said socket means to connect power from said power supply through said igniter means,

flexible linking means interconnecting said projectile and said gun body, and

handle means interconnected with said plate means for vertically supporting said gun body.

5. Apparatus as described in claim 4, wherein said socket means contains water repellant means adapted to be penetrated by said pin.

6. Apparatus as described in claim 4, wherein said switching means includes a first retaining means of a first greater strength arranged to resist movement of said rod away from said socket means, and a second retaining means of a second lesser strength arranged to resist movement of said rod toward said socket means but insufficient to bear the weight of said gun body.

7. Apparatus as described in claim 6, wherein said first and second retaining means comprise shear pins inserted through said rod and having lengths greater than the diameter of said aperture in said plate means.

8. Apparatus for taking a sample of submerged earth substances, said apparatus comprising

a gun body having a bore and a firing chamber,

a breech plug threadably engaged with said gun body adjacent said firing chamber,

a propelling charge of explosive disposed in said firing chamber,

a tubular projectile slideably disposed in said bore with one open end disposed in said bore adjacent said firing chamber and with the other open end extending out of said bore,

a plug means threadably engaging and closing said one open end of said projectile in said bore and having an aperture,

retainer means fixed to said other open end of said projectile and having a plurality of inwardly and upwardly directed flexible finger-like extensions,

a plate means adapted and arranged about said gun body to hydrostatically resist recoil of said gun body upon ignition of said propelling charge,

an electrical power supply mounted on said plate means,

an electrical socket means mounted on said plate means and connected to said power supply,

an electrically-actuated igniter means disposed in said breech plug in close proximity to said propelling charge and also connected to said power supply,

a switching means responsive to the extent of consolidation of earth substances encountered and adapted to enter said socket means to pass power from said power supply through said igniter means,

linking means interconnecting said projectile and said gun body, and

handle means interconnected with said plate means for vertically supporting said gun body.

9. Apparatus for taking a sample of submerged earth substances, said apparatus comprising

a gun body having a bore of a first diameter and a firing chamber of a second smaller diameter,

a breech plug threadably engaged with said gun body adjacent said firing chamber,

a propelling charge of explosive disposed in said firing chamber,

a piston slideably and gas-tightly disposed in said bore adjacent said firing chamber and said propelling charge,

a tubular projectile slideably disposed in said bore with one open end disposed in said bore adjacent said piston and with the other open end extending out of said bore,

a plug means threadably engaging and closing said one open end of said projectile in said bore and having an aperture,

a pre-divided sleeve means slideably disposed in said tubular projectile in the manner of a liner,

retainer means fixed to said other open end of said projectile and having a plurality of inwardly and upwardly directed flexible finger-like extensions,

a plate means adapted and arranged about said gun body and breech plug to hydrostatically resist recoil of said gun body upon ignition of said propelling charge, said plate means having an eccentrically located aperture,

an electrical power supply mounted on said plate means,

an electrical socket means mounted on said plate means above said aperture therein and connected to said power supply,

an electrically-actuated igniter means disposed in said breech plug in close proximity to said propelling charge and also connected to said power supply,

a switching means responsive to the extent of consolidation of earth substances encountered and to the weight of said gun body and other parts of said apparatus, said switching means including a rod slideably arranged along side said gun body and projectile and extending beyond said projectile in one direction and through said aperture in said plate means in the other direction towards but not into said socket means, said rod further having a pin adapted to enter said socket means to connect power from said power supply through said igniter means,

flexible linking means interconnecting said projectile and said gun body, and

handle means interconnected with said plate means for vertically supporting said gun body.

10. Apparatus as described in claim 9, wherein said rod includes a disc means attached thereto and having a diameter functionally related to the extent of consolidation of earth substances sought to be investigated.

11. Apparatus as described in claim 9, wherein said socket means contains water repellant means adapted to be penetrated by said pin.

12. Apparatus as described in claim 9, wherein said switching means includes a first retaining means of a first greater strength arranged to resist movement of said rod away from said socket means, and a second retaining means of a second lessor strength arranged to resist movement of said rod toward said socket means but insufficient to bear the weight of said gun body.

13. Apparatus as described in claim 12, wherein said first and second retaining means comprise shear pins inserted through said rod and having lengths greater than the diameter of said aperture in said plate means.

14. Apparatus for taking a sample of submerged earth substances, said apparatus comprising:

a gun body having a bore and a firing chamber;

a propelling charge of explosive disposed in said firing chamber;

a tubular sample-taking projectile slidingly disposed in said bore with one end located in said bore adjacent said firing chamber and with the other end extending out of said bore;

plug means threadingly engaging and closing the end of said projectile in said bore and having an aperture extending therethrough;

a sleeve removeably disposed in said projectile, said sleeve including two substantially hemi-cylindrical members disposed therein forming a sample receiving bore;

means connected with the other end of said projectile retaining said sleeve therein; and,

ignition means operably connected with said propelling charge for igniting said propelling charge to discharge said projectile, plug, and sleeve from said bore.

15. The apparatus described in claim 14 and also including a piston disposed in the bore in said gun body between said plug and propelling charge, said piston

slidingly and sealingly engaging said gun body and engageable with said plug means to discharge said projectile from said bore upon ignition of said propelling charge.

16. The apparatus described in claim 14, wherein said ignition means includes a member slidingly mounted on said body, said member being moveable relative to said body upon engagement with said submerged earth substance to actuate said ignition means.

17. The sampling apparatus described in claim 16, wherein said member has one end connected with said projectile and is slideable relative to said body whereby said member, upon the engagement of said projectile with said submerged earth substance, actuates said ignition means to ignite said propelling charge.

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