TELESCOPING SEA FLOOR SOIL SAMPLER

12 Claims, 19 Drawing Figs.

ABSTRACT: A deep-penetrating ocean bottom soil sampler employing a plurality of telescoping tubes that may be sequentially driven downwardly to penetrate the ocean floor a distance equal to approximately one-half of the cumulative length of the tubes. As the sampler with extended tubes is withdrawn, it extracts an elongate core comprising a representative ocean bottom soil sample.
TELESCOPING SEA FLOOR SOIL SAMPLER

STATEMENT OF GOVERNMENT INTEREST

The invention described herein may be manufactured and used by or for the Government of the United States of America for governmental purposes without the payment of any royalties thereon or therefor.

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to soil sampling devices and more particularly to deep-penetrating soil samplers employed in obtaining relatively undisturbed ocean bottom samples.

2. Description of the Prior Art

It is suspected that much of the shear strength information that has been published on sea floor soils may be in error because of sample deformation. This is particularly true for deep penetrating soil samples in which the sampling equipment is normally designed to obtain long cores having a fairly large length to diameter ratio. It is believed that the best quality soil samples are obtained by samplers having small length to diameter ratios and which in operation slowly force the sampling tube into the soil.

Previously the length of a soil sample and therefore the penetration depth of the sampling tube has been limited by the amount of core disturbance or deformation which results from frictional contact and scraping between the outside surface of the sample core and the inside surface of the long sampling tube. Such deformation has heretofore effectively limited the length of the sample and therefore the depth from which a satisfactory, relatively undisturbed sample could be obtained.

SUMMARY OF THE INVENTION

The present invention comprises an ocean bottom soil sampler in which a plurality of telescoping tubes are sequentially actuated to extend and penetrate into the ocean floor. As the extended tube assembly is withdrawn, it carries therein a representative ocean bottom soil sample which is relatively undisturbed and, therefore, satisfactory for shear strength and other soil tests.

STATEMENT OF THE OBJECTS OF THE INVENTION

An object of the present invention is to provide apparatus for obtaining ocean floor soil samples.

Another object of the present invention is to provide a relatively compact apparatus capable of obtaining long core ocean floor soil samples, but wherein the core material is relatively undisturbed.

Another object is to provide an improved method of isolating a sample core from the surrounding soil material in progressive steps by the use of interconnected coaxial tubes so that the outer surfaces of adjacent core sections are not disturbed by the passage thereover of a single long sampling tube.

Another object of the present invention is to provide a reliable method and apparatus for retrieving ocean bottom soil samples.

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

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a diagrammatic vertical sectional view showing one embodiment of the sampler of the present invention equipped with a power-operated ram and resting on the ocean bottom with all tubes in telescoped arrangement.

FIGS. 2 through 12 are diagrammatic representations which depict the manner in which successive tubes are forced downwardly into the soil upon successive vertical movements of the ram.

FIG. 13 is a diagrammatic view of portions of three separate tubes showing how each tube and the tube interconnecting clips thereon are attached by tripping straps or cables to next smaller tube.

FIG. 14 is a view similar to that of FIG. 13 in which the straps or cables are in a taut position with the clip tripped and the outer tube free to pass downward.

FIG. 15 is an enlarged view of the tube interconnecting clip shown in FIG. 13.

FIG. 16 is a vertical side elevational view of a sampler assembly with tubes extended and tail vane boom in place.

FIG. 17 is a diagrammatic sectional view of the embodiment of FIG. 16 with the tube sections in place about a core sample.

FIG. 18 is an enlarged elevational view with portions broken away of the central part of the device of FIG. 17.

FIG. 19 is a transverse sectional view taken on a line substantially corresponding to line 19-19 of FIG. 18.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to FIGS. 1—15 of the drawings, the sampler assembly indicated generally as by the reference character 10 comprises a plurality of tubes 12, 13, 14, 15, 16, 17, 18, 19, 20, 21 and 22 each of an increased diameter in order that they may slip over one another in telescoping fashion. Each tube is preferably designed so as to have a small area ratio, a small length to diameter ratio and only a slight inside clearance ratio. If desired the lower end of each tube may be beveled to facilitate entry into the soil.

As shown in FIG. 1 all tubes 12 through 22 of this embodiment are located initially in the same horizontal plane or elevation. A power driven actuating means such as a conventional hydraulic ram mechanism 24 may be mounted on the upper end of a vertical column or support element 25 which extends centrally through the telescoped tubes and is attached to an ocean bottom-engaging base 28. The base is preferably circular or disc like in nature and may be of a diameter closely approximating the inside diameter of tube 12. A tube engaging coupling means 26 may be operatively connected to the ram mechanism 24 and is supported to permit up and down movement in reciprocating cycles. This coupling means 26 is adapted to engage the top edge of one tube at a time successively, beginning with the first or innermost tube 12, and with each downward movement forces that particular tube downwardly into the soil a distance approximately the length of the tube to the position shown diagrammatically in FIG. 2.

It will be noted that after the first complete downward movement of ram 24, the top of tube 12 lies at the level of the fixed base 28 to which it may be secured by any suitable means such as a spring biased catch 29 which may include a spring biased plunger to latch into a groove 27 provided in the top inside wall of the tube 12.

As shown in FIG. 3, the second downward movement of ram 24 forces the second tube 13 down into the soil to the same depth as the first tube 12. At this time, a clip or stop 40 (shown in FIGS. 13, 14 and 15) on tube 13, which clip is normally in the cocked or laterally extended position shown in FIGS. 13 and 15 is engaged by the bottom edge of the third or next larger tube 14 as indicated at point 30. This provides means for interconnecting adjacent tubes and in this instance tube 13 will be forced downwardly by tube 14 as it is likewise moved downwardly by the third downward movement of ram 24 during the third cycle.

As the top of tube 13 reaches a position near the bottom of the tube 12 (FIG. 4), the clip 40 is released in a manner to be described below which thereafter allows tube 14 to move downwardly over tube 13. At the same time the further downward movement of tube 13 is restrained by the strap 44. This sequence of events is repeated as shown in FIGS. 5 through 12 until the entire telescoped tube assembly is fully extended into the soil as shown in FIG. 12.

Referring to FIG. 1 the means 26 for coupling the power driven actuating means to the top end of each successive tube
comprises outwardly biased fingers 34 which may be supported by the outer ends of spaced finger guide rods 32. Each set of guide rods is mounted in the wall of a member 36. This member may be in the form of a disc having a central aperture 35 to receive the vertical column 25 and it will be apparent that several sets of fingers may be located around the edge of the disc if desired. Vertical reciprocation of this disc is achieved by up and down movement of ram pistons or rods 38. Springs 42 may provide the outward bias on fingers 34. It will be observed that with this arrangement fingers 34 engage the upper ends of successively larger tubes during each up-down cycle of pistons or rods 36, successively forcing each tube downward in the manner shown.

There are numerous ways in which the top of a smaller tube may be interconnected or coupled to the bottom of the next larger tube in order that the smaller tube may be forced further downward. One interconnect arrangement is illustrated in FIG. 13 where a short strap or cable 44 is shown attached at one end to the top of tube 12 at point 46 and at the other end to the end of a link 43 of clip 40 recessed in a slotted opening 41 in the next larger tube. The attachment at point 46 may be made in the form of a readily detachable fastener to facilitate core removal in a manner later to be described.

The interconnect clip 40 may comprise an upper link 43 and a lower link 45, the latter resting against an elevated abutment 47 located in the lower part of the slot to retain the links in the cocked position when strap 44 is not taut. In the cocked position the undersurface of link 43 rests upon an abutment 49 forming a part of link 45. It will be noted that as tube 14 moves downwardly the strap 44 becomes taut thereby straightening the clip links and allowing the larger tube to move downwardly over the tipped clip as illustrated in FIG. 14.

The hydraulic ram assembly, and associated means for transmitting the ram movement to the top of each successive tube as described above, is only one of many power mechanisms that may be employed to force the tubes the desired distance into the soil. Vibrators, weights or other mechanisms may also be used, either independently or in combination with the ram means shown, as the means for propelling the tubes into the soil. For this purpose a source of vibration is indicated generally by FIG. 1 by the reference character 48. This may be controlled by any suitable means to impart vibration to the vertically reciprocating member 36.

In a modification of the present invention a somewhat different mode of operation is contemplated, though the resulting soil sample core is similar. This modification is illustrated in FIGS. 16 to 19 and does not employ the vertically reciprocating ram device 24 of the first embodiment. Instead, to force the sampler assembly into the ocean floor, this embodiment employs the momentum of its fall through the water, or some other source of energy such as a pile driving action applied to the overall sampler, or a thrust mechanism which may react against the ambient water.

This modification is shown in FIG. 16 in its normal extended tube condition ready to be dropped into the ocean bottom. As shown the entire assembly is suspended from a cable 68 which passes through a vaned stabilizing ring or shroud assembly 70 and down through the hollow center of an elongate stabilizing fin assembly supporting boom 71. In this modification the sampler assembly comprises a number of extended tubes ranging from the smallest tube 50 at the bottom (FIG. 16) through successively larger tubes 52, 54, 56 and 58 and terminating in a much longer outer tube 60. As shown the cable 68, after passing through the boom 71 and the extended tubes 52 to 60, is fastened at its lower end by any suitable anchor means such as fitting 69, to a crossmember 51 extending across the upper end of the tubes 50.

A hanging 64, spaced a short distance above the upper end of the elongate outer tube 60 by brackets 63, may contain a heavy weight, or it may enclose a power driven mechanism of the pile driver or other type designed to impart a downward thrust to the large tube 60 and the interconnected assembly of smaller tubes. It will be apparent that the power means employed may include shifting weights which have a pile driver action, a propeller-reciprocating cable arrangement, or the like. The downward thrust is obtained by forcing the surrounding water upwardly, or reaction force may be generated through propellant gases exhausting upwardly from nozzles 66 in a manner well known in connection with jet thrust action on underwater vehicles.

The device of this embodiment may be released for free fall descent to the deep ocean floor or it may be driven down to the support cable 68 which is then payed out from the surface ship or platform. When the extended telescoping tube arrangement of FIG. 16 reaches the ocean floor the successive tubes are compacted into each other so that tube 50, after entering the soil and surrounding the top portion of the core sample, comes to rest with its upper end crossmember 51 resting on the top end of the soil sample. At this point shear pins 53, of relatively low resistance, sever and permit the next outer tube 52 to slide downwardly over the surface of tube 50. Since tubes 50 to 58 each have the strap or cable interconnecting means illustrated in FIGS. 13 to 15 they will successively be driven into place past the smaller tube element and will be forced further into the soil, until ultimately the large outer tube 60, responding to downward force from whatever power source is employed, fully encloses the now reversely arranged assemblage of telescoped tubes and comes to rest in the fully buried position shown in FIG. 17. It will be noted that in this FIG. the interfitting arrangement of associated tubes, together with the interconnecting means of FIGS. 13--15, has caused each successive tube to enclose only its associated portion of the complete soil sample. Hence the core specimen is enclosed in essentially the same fashion as the specimen diagrammatically depicted in Figs. 2--12 inclusive, though in this modification the outer set of tubes 18--22 have been replaced by a single long tube 60.

FIG. 18 shows enlarged details of the central portion of FIG. 17. As shown the large outer tube 60 has an end piece or crosspiece 61 which is shown in the form of a disc and may be provided with a series of open passages 62 through which water entrapped in the sampler may be vented. Brackets 63 support centrally apertured housing 64 spaced a distance above the top surface of disc 61. This component has a central passage 76 through which passes hollow boom shaft 71 threaded at its lower end into the crossmember 61 located at the upper end of tube 60. Through the hollow shaft 71 passes the suspension cable 68 which terminates in cable anchor fitting 69 threaded into the crossmember 51 of the smallest tube 50. With the arrangement just described it will be apparent that upward movement of the cable 68 lifts crossmember 51 and all the elements thereabove.

Instead of containing a weight, housing 64 may mount any suitable power means for driving the entire assembly downwardly in the event that the weight of the device and the momentum acquired during its fall is not sufficient to cause full sampler penetration when it strikes the ocean floor. For this purpose the housing may house a vertically reciprocating mass to give a pile-driver effect to the whose sampler in a manner well known in the art. This mass may be operated by a self-contained energy source or by electrical or other energy received through the suspension cable 68 or through other cable or hose assemblies. As another form of propulsion a propeller arrangement may be employed which may also be so powered. Also, reaction from exhaust of an underwater propellant, discharged upwardly through nozzles 66 may be used to force the soil sampler tubes down into the ocean bottom.

It will be apparent that with both of the embodiments discussed a relatively undisturbed sample core will be obtained since successive sections of the core are sampled within separate tubes and no portion of the core surface is subjected to extensive scrapping or rubbing action by the inside of a succeeding tube.

From the foregoing it will be apparent that through the use of a plurality of telescoping tube sections, each section enclos-
3,576,220

power driven-actuating means having an up and down movement;

means for coupling each of said nested tubes to said actuating
means on successive down strokes thereof for driving
said tubes downwardly into the soil to be sampled; and

means for interconnecting adjacent tubes for movement
together into the soil so that when the device is fully ex-
tended the soil sample is enveloped within a casing
formed of extended tubes.

2. The device of claim 1 wherein the coupling means is in
the form of outwardly biased fingers which overlie the top
derge of a tube and by which downward movement of the
power driven-actuating means is communicated to cause
downward movement of the tube.

3. The device of claim 1 wherein the power driven-actuating
means is supported upon a base having a diameter only slightly
less than the diameter of the tube being driven so that the base
provides initial guidance for downward movement of the tube.

4. The device of claim 2 wherein the coupling means and
fingers automatically engage the upper ends of progressively
larger tubes so that each is successively driven into the soil.

5. The device of claim 1 wherein the means for intercon-
tecting adjacent tubes for movement together into the soil in-
cludes a stop mounted upon one of the tubes and moveable
into engagement with an adjacent tube.

6. The device of claim 5 wherein said stop is automatically
withdrawn from such engagement when the tubes have been
un telescoped to a predetermined extent.

7. A soil-sampling device adjustable from a low length-to-
diameter ratio to a high length-to-diameter ratio to facilitate
extracting a deep soil core comprising:

a first hollow tube,

additional hollow tubes disposed in nested relationship with
said first tube,
said tubes when telescoped forming an open ended passage
having a low length-to-diameter ratio, and when extended
forming an open ended passage having a high length-to-
diameter ratio,

means for causing said telescoped tubes to extend from the
low length-to-diameter ratio position to the high length-
to-diameter ratio position to thereby engage the passage
formed thereby,

and means for maintaining the extended position relation-
ship of said tubes so that an enclosed core sample is pro-
tected during extraction of the sampling device from the
soil.

8. A deep-penetrating soil-sampling device comprising:
a plurality of tubes nested one within the other and movea-
ble from a nested position to an extended position,
interconnect means coupling each smaller tube with its next
larger tube,
said interconnect means including a retractable stop
mounted on each smaller tube and normally urged into the
path of the next larger tube,
means for retracting said stop out of the path of the next
larger tube,
said last-named means being actuated upon the other tube
reaching the extended position.

9. The device of claim 8 wherein the means for retracting
the stop comprises a lanyard secured at one end to the inner
tube and at the other end to the retractable stop.

10. In a device for facilitating the extraction of a sample of
soil from a region relatively difficult of normal access, said
device being designed for placement on the surface of such
region and being controllable from a remote point, the combina-
tion of:
a plurality of hollow tubular members of progressively in-
creasing diameters arranged coaxially and lying with their
common axis essentially normal to the surface of the soil
a sample of which is to be extracted, said members being
of essentially similar lengths and lying contiguously in a
compact nested relationship.
power-operated means for sequentially driving each of said tubular members down into the soil to penetrate the latter for a distance approximately equal to the length of such member, the sequence of such driving being in a radial direction with respect to the common axis of such members, and
means interconnecting each individual member of said plurality, with the exception of the innermost and outermost, with the two members lying on opposite sides thereof, such that a downward movement of any particular member tends to cause all members except the first which have been previously driven by said power means to penetrate the soil for a further distance approximately equal to their individual lengths,
with the interconnecting means between said members acting to restrict the penetration of any individual member to a depth not exceeding that defined by its own length plus a distance equal to the total lengths of all of the members previously driven by said power means,
said plurality of tubular members, after having been driven by said power means, defining an elongated assembly enclosing the sample of soil the extraction of which is desired, the total length of such elongated assembly being approximately equal to half the sum of the lengths of all of the members of said plurality.

11. The method of extracting long core soil samples from the ocean floor with minimum distortion and damage to the sample comprising the steps of:
forcing a first tube of selected diameter into the soil to be sampled so as to establish a barrier around an initial portion of a soil sample;
forcing a second tube of slightly greater diameter over the first tube and further into the soil so as to establish a similar barrier around a second portion of the soil sample said second portion constituting a continuation of said initial portion of said soil sample;
forcing additional tubes, each of slightly greater diameter than the previous tube into the soil, said additional tubes each passing over the previous tube and into the soil to form a barrier about its respective encased portion of the soil sample; and
extracting the entire core sample at one time with the tubes in extended relationship.

12. The method of claim 11 wherein:
the process is repeated in reverse after extraction of the sampler from the soil by collapsing the telescoped tubes starting with the last applied tube so as to extract an undamaged core from the tube assembly when fully collapsed.