



## Standard Guide for Core Sampling Submerged, Unconsolidated Sediments<sup>1</sup>

This standard is issued under the fixed designation D 4823; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon ( $\epsilon$ ) indicates an editorial change since the last revision or reapproval.

### 1. Scope

1.1 This guide covers core-sampling terminology, advantages and disadvantages of different types of core samplers, core-distortions that may occur during sampling, techniques for detecting and minimizing core distortions, and methods for dissecting and preserving sediment cores.

1.2 In this guide, sampling procedures and equipment are divided into the following categories based on water depth: sampling in depths shallower than 0.5 m, sampling in depths between 0.5 m and 10 m, and sampling in depths exceeding 10 m. Each category is divided into two sections: equipment for collecting short cores and equipment for collecting long cores.

1.3 This guide emphasizes general principles. Only in a few instances are step-by-step instructions given. Because core sampling is a field-based operation, methods and equipment must usually be modified to suit local conditions. This modification process requires two essential ingredients: operator skill and judgment. Neither can be replaced by written rules.

1.4 Drawings of samplers are included to show sizes and proportions. These samplers are offered primarily as examples (or generic representations) of equipment that can be purchased commercially or built from plans in technical journals.

1.5 This guide is a brief summary of published scientific articles and engineering reports. These references are listed in this guide. These documents provide operational details that are not given in this guide but are nevertheless essential to the successful planning and completion of core sampling projects.

1.6 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.* For specific hazard statements, see Note 1 and Note 2.

### 2. Referenced Documents

#### 2.1 ASTM Standards:

D 420 Guide to Site Characterization for Engineering, Design, and Construction Purposes<sup>2</sup>

D 1129 Terminology Relating to Water<sup>3</sup>

D 1452 Practice for Soil Investigation and Sampling by Auger Borings<sup>2</sup>

D 1586 Test Method for Penetration Test and Split-Barrel Sampling of Soils<sup>2</sup>

D 1587 Practice for Thin-Walled Tube Geotechnical Sampling of Soils<sup>2</sup>

D 4220 Practice for Preserving and Transporting Soil Samples<sup>2</sup>

D 4410 Terminology for Fluvial Sediment<sup>3</sup>

### 3. Terminology

3.1 *Definitions*—For definitions of terms used in this guide, refer to Terminology D 1129 and Terminology D 4410.

#### 3.2 Definitions of Terms Specific to This Standard:

3.2.1 *check valve*—a device (see Fig. 1)<sup>4</sup> mounted atop an open-barrel core sampler. As the sampler moves down through water and sediment, the valve remains open to allow water to flow up through the barrel. When downward motion stops, the valve closes. During retrieval, the valve remains closed and creates suction that holds the core inside the barrel.

3.2.2 *piston sampler*—a core sampler (see Fig. 2) with a solid cylinder (piston) that seals against the inside walls of the core barrel. The piston remains fixed at the bed-surface elevation while the core barrel cuts down through the sediment.

3.2.3 *core*—a vertical column of sediment cut from a parent deposit.

3.2.4 *core catcher*—a device (see Fig. 3) that grips and supports the core while the sampler is being pulled from the sediment and hoisted to the water surface.

3.2.5 *core conveyor*—a device (see Fig. 4) for reducing friction between a core and the inside surface of a core barrel.

3.2.6 *core-barrel liner*—a rigid, thin-wall tube mounted inside the barrel of a core sampler. During the core-cutting process, sediment moves up inside the liner.

3.2.7 *core sampler*—an instrument for collecting cores.

3.2.8 *extrude*—The act of pushing a core from a core barrel or a core-barrel liner.

3.2.9 *open-barrel sampler*—in simplest form, a straight tube open at both ends. More elaborate open-barrel samplers have core catchers and check valves.

3.2.10 *trip release*—a mechanism (see Fig. 2 and Fig. 5(b))

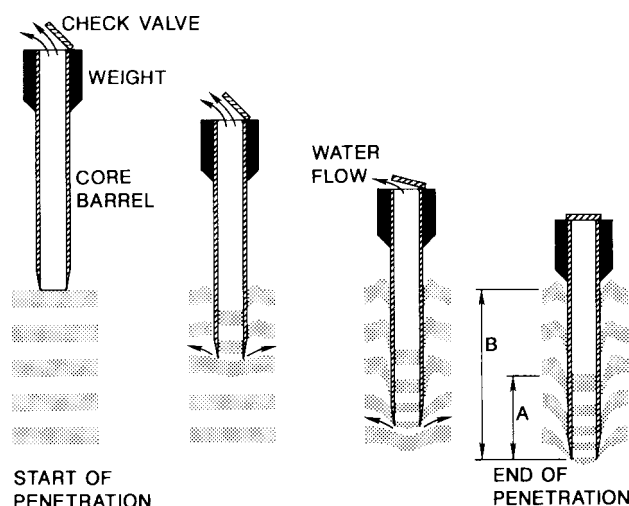
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<sup>2</sup> *Annual Book of ASTM Standards*, Vol 04.08.

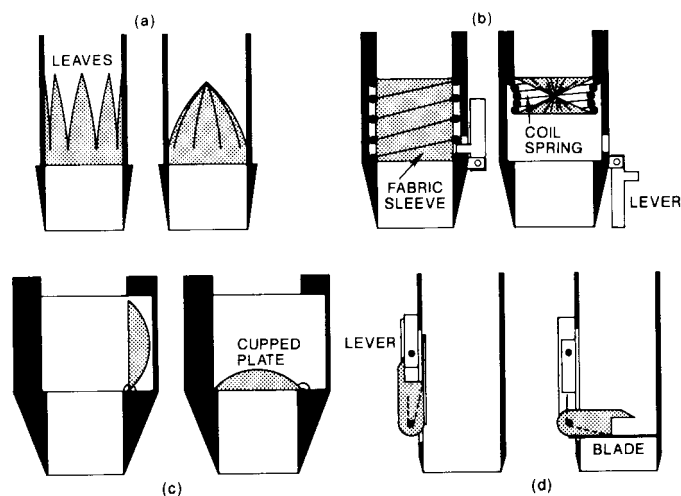
<sup>3</sup> *Annual Book of ASTM Standards*, Vol 11.01.

<sup>4</sup> The boldface numbers in parentheses refer to the list of references at the end of this guide.



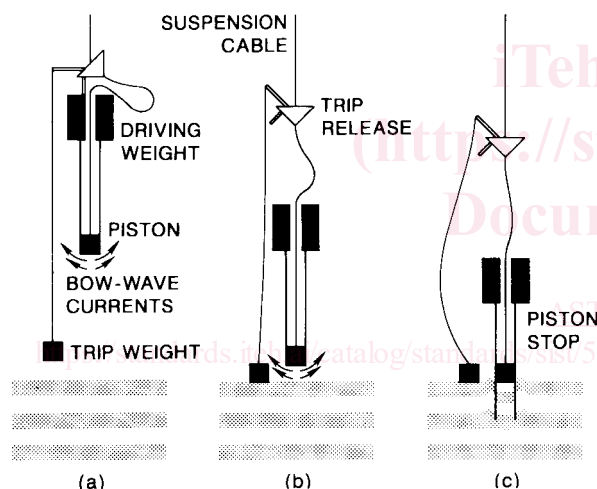
NOTE 1—Dark bands represent stiff sediments; light bands represent plastic sediments. As coring proceeds, sediment below the barrel moves laterally away from the cutting edge and plastic sediments inside the barrel are compressed. "A" is the core's length and "B" is the barrel's penetration depth.

FIG. 1 Deformations Caused by Open-Barrel Core Samplers (1) 4



NOTE 1—(a) The leaves separate during penetration and then close during retrieval. Strips of gauze can be woven around the leaves to provide additional support. (3) (b) The lever trips down during retrieval to release the spring and twist the fabric sleeve shut. (4) (c) The cupped plate drops during retrieval to block the entrance and support the core. (4) (d) The lever releases the spring-loaded blade which pivots downward to hold the core. (4)

FIG. 3 Core Catchers



NOTE 1—(a) The sampler is lowered slowly through the water. (b) The sampler falls free when the trip weight contacts the bed. (c) The core barrel cuts downward but the piston remains stationary.

FIG. 2 Operation of a Piston-Type Core Sampler (2)

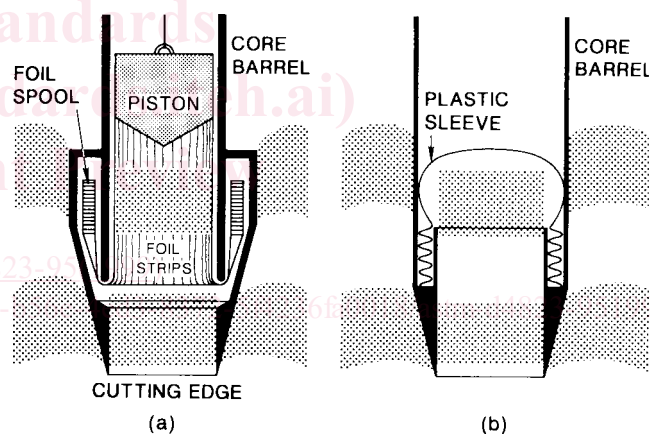
that releases a core sampler from its suspension cable and allows the sampler to freely fall a predetermined distance before striking the bed.

3.2.11 *piston immobilizer*—a special coupling (see Fig. 6) that protects a core from disruptive forces that arise during sampler pull-out. Piston immobilizers are also called *split pistons* or *break-away pistons*.

3.2.12 *recovery ratio*—the ratio A/B where "A" (see Fig. 1) is the distance from the top of the sediment core to the bottom of the cutting bit and "B" is the distance from the surface of the parent deposit to the bottom of the cutting bit.

3.2.13 *repenetration*—a mishap that occurs when a core sampler collects two or more cores during one pass.

3.2.14 *surface sampler*—a device for collecting sediment



NOTE 1—(a) Strips of metal foil slide up through the core barrel as the cutting edge advances downward. (5) (b) The plastic sleeve unfolds from pleats stored near the cutting edge. This sleeve surrounds the core as the barrel moves down. (4)

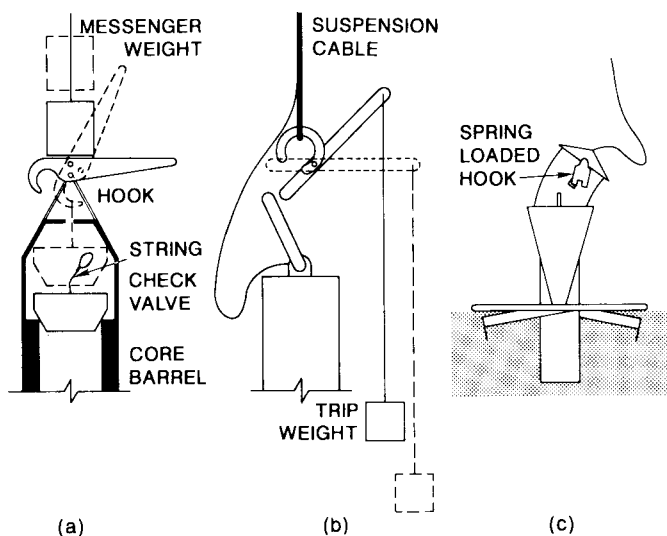
FIG. 4 Core Conveyors

from the surface of a submerged deposit. Surface samplers are sometimes referred to as grab samplers.

3.2.15 *undisturbed sample*—sediment particles that have not been rearranged relative to one another by the process used to cut and isolate the particles from their parent deposit. All core samples are disturbed to some degree because raising the cores to the water surface causes pore water and trapped gases to expand (10). In common usage, the term "undisturbed sample" describes particles that have been rearranged but only to a slight degree.

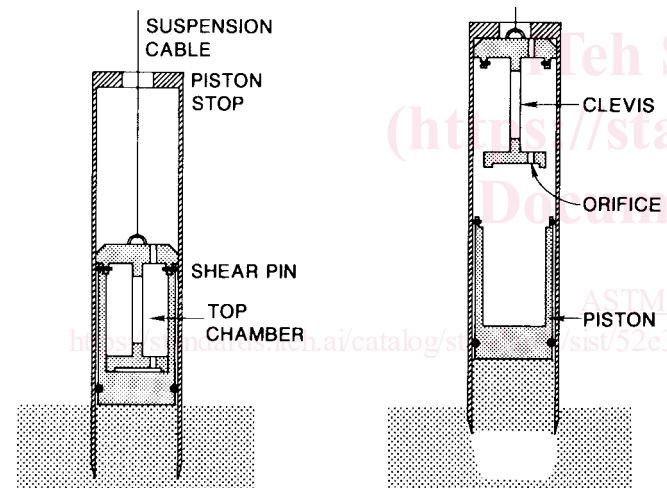
#### 4. Critical Dimensions of Open-Barrel and Piston Samplers

4.1 Dimensions of a sampler's cutting bit, core tube, and



NOTE 1—(a) The messenger weight strikes the hook and releases the string holding the check valve. (6) (b) The trip weight strikes the sediment and unhooks the sampler. (7) (c) The cable slackens and allows the spring-loaded hook to open. (8)

FIG. 5 Release Mechanism



NOTE 1—During penetration the shear pins break but the flow-restricting orifice holds the clevis and piston together. During retrieval, water in the top chamber flows through the orifice and allows the piston and clevis to separate. Cable tension pulls the clevis up against the stop but friction locks the piston and core barrel together.

FIG. 6 Piston Immobilizer (9)

core-tube liner (see Fig. 7) are critical in applications requiring undisturbed samples. These dimensions control the amount of distortion in recovered cores. The recommendations in this section were developed from tests on open-barrel core samplers (11); however, the recommendations are usually extended to cover piston-type core samplers.

4.2 *Cutting-Bit Angle*—The angle “b” on the cutting bit (see Fig. 7) should be less than about 10°; the optimum angle is about 5°. If the angle is smaller than about 2°, the bit cuts efficiently but its edge chips and dulls easily.

4.3 *Core-Liner Diameter,  $D_s$*  (see Fig. 7)— $D_s$  should be larger than about 5 cm; however, the upper limit for  $D_s$  is

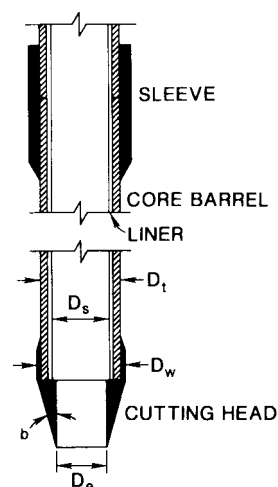


FIG. 7 Critical Dimensions for Cutting Bits and Core Barrels (11)

difficult to establish. As  $D_s$  increases, the amount of core compaction decreases but the sampler becomes heavier and larger. A survey of existing samplers shows that 10 cm is a practical upper limit. A few samplers have barrels larger than 10 cm but these are used only for special applications (12).

4.4 *Inside Friction Factor*—The dimensions  $D_s$  and  $D_e$  (see Fig. 7) set the inside friction factor defined as  $C_i = (D_s - D_e)100/D_e$ . For a barrel without a core conveyor, the optimum  $C_i$  value depends mainly on the barrel’s length.  $C_i$  should be smaller than 0.5 if the barrel is shorter than about 2 m. If the barrel is longer than about 2 m,  $C_i$  should fall between 0.75 and 1.5. For a barrel with a core conveyor,  $C_i$  should be smaller than 0.5 regardless of the barrel’s length. Notice that in all instances  $D_s$  is lightly greater than  $D_e$ . The small expansion above the cutting bit minimizes friction where the outside of the core contacts the inside of the barrel or liner. Friction distorts the core’s strata by bending horizontal layers into curved, bowl-shaped surfaces shown on the upper part of Fig. 8. Friction also causes overall end-to-end compaction of the core and thereby reduces recovery ratios. If friction becomes very large, sediment fails to enter the cutting bit. Instead, sediment moves aside as the bit penetrates downward. This lateral motion, commonly referred to as “staking,” prevents

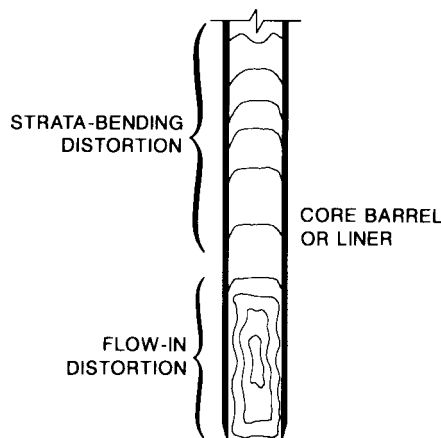


FIG. 8 Flow in and Strata-Bending Distortions Inside a Core Barrel (13)

deep-lying strata from being sampled. It is important to observe upper limits on  $C_i$  because too large an expansion causes another form of distortion, the core slumps against the walls as the sediment slides up into the barrel.

**4.5 Outside Friction Factor**—The dimensions  $D_w$  and  $D_t$  (see Fig. 7) set the outside friction factor defined as  $C_o = (D_w - D_t)100/D_r$ .  $C_o$  should be zero for barrels used in cohesionless sediments; but  $C_o$  should be between 1.0 and about 3.0 for barrels used in cohesive sediments. Notice that in all instances  $D_w$  is larger than  $D_r$ . The small contraction above the bit reduces friction at the outside surface of the barrel and makes it easier to push the core barrel into the bed. On a long barrel, friction can be reduced by installing one or more sleeves (see Fig. 7). The sleeves not only plough a path for the barrel but they also serve as clamps to hold barrel sections together.

**4.6 Area Factor**—The dimensions  $D_w$  and  $D_e$  set the area factor defined as  $C_a = (D_w^2) 100/D_e^2$ .  $C_a$  should be less than 10 or possibly 15. Notice that  $C_a$  is proportional to the area of sediment displaced by the bit divided by the area of the bit's entrance; therefore,  $C_a$  is an index of disturbance at the cutting edge. A sampler with too large an area factor tends to oversample during early stages of penetration when friction along the inner wall of the barrel is low. Oversampling occurs because sediment laying below and outside the bit shift inward as the bit cuts downward.

**4.7 Core-Barrel Length**—A sampler's core barrel should be slightly longer than  $L$ , the longest core that can be collected without causing significant compaction.  $L$  and  $D_s$  (see Fig. 7) set the core-length factor defined as  $L_f = L/D_s$ .  $L_f$  should be less than 5.0 (or possibly 10) for a sampler used in cohesive sediments, but  $L_f$  should be less than 10 (or possibly 20) for a sampler used in cohesionless sediments. The constant factors 5, 10, and 20 apply to slow-penetrating, open-barrel samplers. Studies suggest that all of these factors can be increased by raising the sampler's penetration speed or using a piston sampler instead of an open-barrel sampler.

**4.8 Barrel Surfaces**—All surfaces contacting the core should be smooth and free of protruding edges to reduce internal friction and minimize core distortion. The surfaces should also be clean and chemically inert if the core is to be analyzed for contaminants or if the core is to be stored in its liner for long periods of time.

**4.9 Chemical Composition of Sampler Parts**—Sampler parts must not contain substances that interfere with chemical analysis of the cores. For example, barrels, pistons, and core catchers made of plastic should not be used if tests include phthalate concentrations. Misleading data will result from plasticizer contamination of the sediments.

## 5. Open-Barrel Samplers Versus Piston Samplers

**5.1** Users sometimes face difficult decisions in choosing between an open-barrel sampler and a piston sampler. The decision frequently depends not only upon characteristics of the two samplers but also upon other factors such as hoisting-equipment capabilities, working platform stability, water depth, operator experience, and the purpose for collecting the cores. This section covers factors to consider before making the final choice.

**5.2 Depth of Penetration**—Most open-barrel samplers and

most piston samplers rely on momentum to drive their barrels into sediment deposits. Momentum-driven samplers are released at a predetermined point so as to acquire momentum while falling toward the bed. A momentum-driven piston sampler generally penetrates deeper than a momentum-driven open-barrel sampler provided the two samplers have equal weights, equal barrel-diameters, and equal fall-distances (2).

**5.3 Core Compaction**—When compared under equal test conditions (see 5.2), a piston sampler causes less core compaction than an open-barrel sampler. However, the piston must be held motionless at the bed-surface elevation while the barrel penetrates downward. If the piston is allowed to shift down with the barrel, the core undergoes serious compaction.

**5.4 Flow-in Distortion**—Flow-in distortion is caused by suction at the entrance of a sampler. Sediment is sucked into the barrel instead of being severed and encircled by the cutting edge. Flow-in rarely occurs with open-barrel samplers; however, it can be a problem with piston samplers (14). Flow-in usually occurs during pull-out following a shallow penetration. Conditions leading to flow-in are shown in Fig. 2(c). The barrel is at the end of its downward travel but the piston lies below the piston stop. During pull-out, the upward force on the cable slides the piston up through the barrel before the cutting edge clears the bed. As the piston slides, it pulls the core up through the barrel. As the core moves, sediment flows in to fill the void at the lower end of the barrel. Strata lines at the bottom of the recovered core are distorted and resemble those in Fig. 8. A piston immobilizer helps prevent flow-in distortion by breaking the connection between the cable and the piston during the pull-out process.

**5.5 Surface Disturbance**—Surface sediment, material lying at the interface between water and bed, is easily disturbed by bow-wave currents (see Fig. 2(a)) that travel ahead of a sampler's cutting bit. A piston sampler creates a strong bow wave as the barrel, which is blocked by the piston, falls through the water. Fine-grained, unconsolidated sediments are blown aside just before the cutting edge contacts the bed. An open-barrel sampler creates a weak bow-wave because the barrel is unobstructed. However, adding a core catcher or a check valve to an open-barrel sampler restricts water flow through the barrel and makes the bow-wave stronger. Check valves come in a variety of sizes, shapes, and styles. These characteristics should be carefully considered before making a final selection. The valve should have an opening approximately equal to the cross-sectional area of the barrel. The valve should open fully during the sampler's descent and then close and seal tightly during the sampler's ascent.

**5.6 Repenetration**—Repenetration occasionally occurs in shallow-water sampling if the working platform (boat or barge) rolls and heaves; however, repenetration usually occurs in deep-water sampling that requires a long cable (1). During the initial stage of pull out, the cable stretches as tension gradually increases. Suddenly, the sediment relaxes its grip on the barrel and the lower section of cable contracts as the sampler springs upward. A rapid sequence of events follow. A shock wave races up the cable, reflects off the hoist drum, and then travels back down to the sampler (15). Upon reaching the bottom, the shock wave abruptly lowers the sampler and the cutting bit cores the

top layer of sediment a second time. This up and down bobbing action, may occur several times before the sampler can be hoisted to a safe level above the bed. The severity of re-penetration depends on the type of sampler used. With an open-barrel sampler, the first core that is cut can shift up the barrel and easily escape through the check valve as additional cores enter the bit. With a piston sampler, the first core fills the barrel if the sampler cuts to full penetration. Since the first core cannot move past the piston, the sampler offers high resistance to re-penetration.

## 6. Driving Core Samplers into Sediment Deposits

6.1 Two techniques are frequently used to drive core samplers into sediment deposits. One technique depends entirely on weight. A weight-driven sampler is lowered slowly until friction along the barrel wall stops downward penetration. The other technique is based on momentum. A momentum-driven sampler is dropped from a specified height by a trip-release mechanism. As the sampler falls, it gains momentum that drives the barrel into the deposit. Paragraphs 6.2-6.6 cover other driving techniques that are occasionally used in special situations.

6.2 *“Free” Core Samplers*—Operation of a “free” core sampler, sometimes referred to as a “boomerang-core sampler” or a “free-fall corer” is shown in Fig. 9. The sampler is dropped into the water and then gains speed and momentum by falling through the entire water column (see Fig. 9(a)). After the core barrel has reached full penetration (see Fig. 9(b)), a latch (not shown) disconnects the core barrel and float from the heavily weighted lower section (Fig. 9(c)). The lower section remains on the bed; however, the float, core barrel, and core sample rise to the water surface (Fig. 9(d)) where they are retrieved. Free corers are useful if many samples must be collected rapidly. Free corers are costly to operate because the lower sections must be replaced and because the latches sometimes fail.

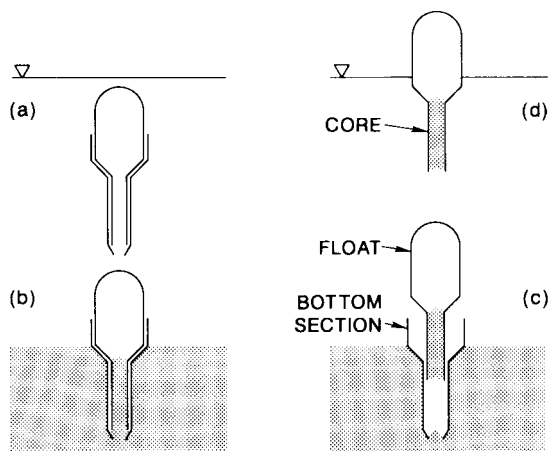
6.3 *Implosive and Explosive Samplers*—These samplers are driven by high pressures developed by either implosions or explosions (16). An implosive-driven sampler has an electrically operated valve and a cylindrical cavity fitted with a

piston. The sampler is lowered to the bed, then the valve is opened so that high-pressure water around the sampler can rush into the cavity and push against the piston. As the piston slides, it pulls against cables (or rods) which exert a downward thrust on the barrel and upward thrust on the sampler’s frame. Implosive samplers are complicated, expensive to purchase, and restricted to deep-water applications. However, the samplers have the advantage of being lighter than momentum-driven samplers. An explosive-driven sampler has a charge that detonates when the sampler touches bottom. The expanding gas produces a strong downward force on the core barrel. Using explosive-driven samplers has a redeeming feature in that they are lighter than momentum-driven samplers.

NOTE 1—**Warning:** Because of the possibility of injury when using explosive samplers, it is suggested that specially trained personnel handle this apparatus.

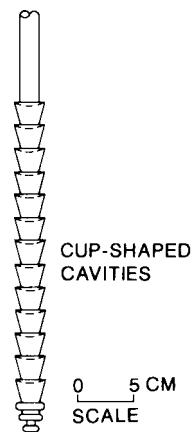
6.4 *Punch-Corer Samplers*—Punch corers are pushed downward by using a stiff rod connected to a jack, drill rig, or heavy weight. The samplers may be either open-barrel or piston types. Punch corers are commonly used in shallow water. Maximum operating depths are set primarily by the rigidity and length of the push rod. A sampling spud (Fig. 10) is a form of punch corer since the spud is pushed with a rod; however, the spud does not collect a true core sample. Instead, small specimens of sediment are trapped in the cup-shaped cavities. Color, softness, and grain-size profiles along the spud are approximate indexes of profiles in the sampled deposit.

6.5 *Vibratory-Driven Samplers*—High-frequency vibration helps to reduce friction on a core barrel. Sediment is pulsed away from the barrel, then the sampler advances downward a short distance. Pulsing and advancing alternates rapidly so that the barrel cuts downward at a nearly uniform rate. The vibrator (see Fig. 11) which is fastened to the top end of the core barrel, receives power through an electric cable or compressed-air tube. Sediment grains inside the core are realigned by the vibration; however, compaction and strata-bending are nearly eliminated. Vibratory-driven samplers can be used through a broad range of water depths. According to Hubbell and Glenn (18), the samplers work especially well in sandy sediments that are difficult to penetrate with other types of core samplers.



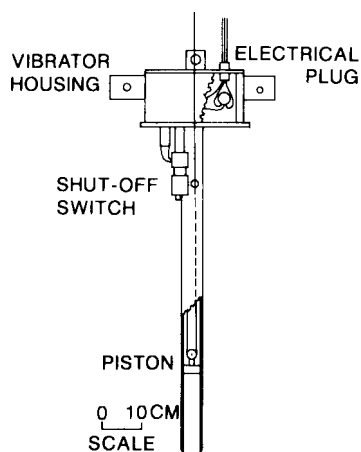
NOTE 1—(a) The sampler falls toward the bed. (b) The bottom section drives the core barrel into the sediment. (c) The bottom section unlatches and releases the float. (d) The float and core rise to the surface.

**FIG. 9 Operation of a Free Corer (2)**



NOTE 1—The spud is pushed or driven into the sediment deposit. As the spud is pulled up, sediment becomes trapped in the cup-shaped cavities.

**FIG. 10 Sampling Spud (17)**



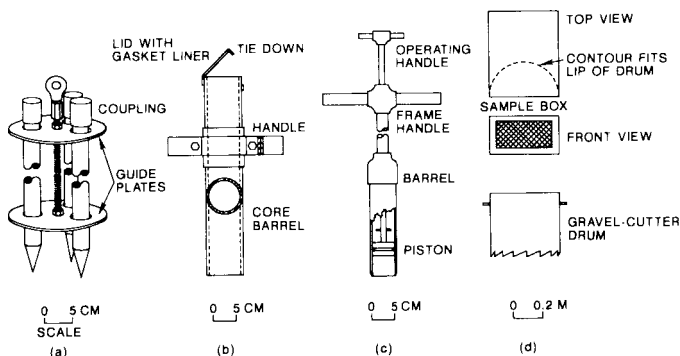
**FIG. 11 Vibratory-Type Core Sampler (19)**

**6.6 Impact-Driven Samplers**—Some gravity deposits that cannot be penetrated with open-ended barrels, can be pierced with pointed pipes (see Fig. 12( a)) driven with a heavy hammer. The pipes are filled with carbon-dioxide gas which slowly freezes the surrounding sediment. When freezing is complete, the pipes along with their load of frozen sediment are pulled free with a hoist suspended from a portable tripod.

**7. Samplers for Specific Field Conditions**

**7.1 Collecting Short Cores in Shallow Water:**

**7.1.1 The Van Stratten sampler** shown in Fig. 12(b) has been found satisfactory for the purpose of coring soft, cohesive sediments covered by water shallower than about 50 cm. This sampler is easy to make with a lathe and ordinary hand tools. The core barrel is a pipe with a diameter of about 10 cm and a length of about 60 cm. On thick-walled pipe, one end must be turned to form a sharp cutting edge: on thin-walled stove pipe, no sharpening is required. Scribe a vertical reference line on the outside surface if north-south alignment of the core is important in subsequent laboratory analysis. The stove-pipe has a seam that serves as a ready-made reference line. Glue a rubber sheet under the lid to form a water-tight seal with the



**NOTE 1**—(a) The cryogenic-gravel sampler, a freeze-type sampler. (20) (b) The Van Stratten sampler, an open-barrel sampler. (4) ( c ) The BMH-53, a piston sampler. (21) (d) The gravel-cutting sampler. (22)

**NOTE 2**—Fig. 12(b) has been reprinted from Bouma, A. H., *Methods for the Study of Sedimentary Structures*, 1969, with the permission of John Wiley and Sons, Inc., New York, NY.

**FIG. 12 Core Samplers for Water Depths Less Than About ½ m**

pipe’s upper edge. To use the sampler, first loosen the lid and align the reference mark. Then apply a steady pressure to force the sampler down into the sediment. Avoid hammering; it disturbs the core and usually fails to increase penetration. Holding the core inside the barrel during pullout is sometimes difficult. One solution is to excavate sediment from around the pipe and push a flat plate under the core. The pipe, plate, and core can then be lifted as a unit. Another solution is to fill the pipe brimful with water and then close and seal the lid. The suction formed during pullout helps to support the core.

**7.1.2 The BMH-53 sampler** shown in Fig. 12(c) has been found satisfactory for the purpose of coring sandy sediments that are difficult to penetrate with the sampler shown in Fig. 12(b). A BMH-53 sampler is frequently used for sampling beds of wadeable rivers. The operating handle is connected to the piston and the frame handle is connected to the core barrel. Before collecting a sample, push the two handles together to set the piston flush with the barrel’s cutting edge. Set the cutting edge against the bed and then cut the core by pressing down on the frame handle while holding the operating handle stationary. A slight rocking motion may be necessary to achieve full penetration and break the core loose from the bed. To retrieve the core, first grip the stem of the operating handle so that the piston cannot shift inside the barrel and then quickly lift the sampler above the water. To eject the core, push the handles together and catch the sediment in a clear carton. If the core slumps, it must be regarded as a highly disturbed sample.

**7.1.3 Gravel beds** can be sampled with the cryogenic sampler shown in Fig. 12(a). The pointed stainless-steel stakes are 1.3-m long sections of 2.5-cm pipe. Using a sledge, drive the stakes through holes in the guide plates and down into the bed. The flat guides hold the stakes upright and maintain a 7.6 cm spacing between centers. After all three stakes have been seated, connect the couplings to the manifold on a 9 kg CO<sub>2</sub> fire extinguisher fitted with a hand-wheel valve. When the valve is opened, cold CO<sub>2</sub> fills the pipes and freezes the sediment to the stakes. Lift the entire unit out of the bed with a hoist suspended from a portable tripod erected over the sampler. Collect subsamples of the stratified-sediment layers by first laying the stakes and frozen core across metal boxes placed side-by-side. About seven boxes, each 10 cm wide, are usually required. As the sediment thaws, particles fall into the boxes and are segregated according to position along the core. A blowtorch helps to speed the thawing process.

**7.1.4 Another gravel-bed sampler** is shown in Fig. 12(d). The gravel cutter, a ½-m diameter cylinder, is turned and pushed into the bed by hand. Serrations on the cutting edge help to plow through sand and gravel-size particles. When the cutter is in place, sediment is excavated layer-by-layer and placed in the sample box. If desired, samples can be sieved through the screened opening.

**7.1.5 A lightweight sampler** for use in shallow, cobblebed streams (36) can be made by removing both ends from a 30 gallon barrel. By pressing down on the cylinder formed by the barrel walls, a circular section of stream bed and the water column above it are isolated and shielded from the flow. Fine grains lying on or between the cobbles can then be lifted and entrained by circulating the trapped water through a small