# *A New Unattached Sediment Sampler*[1]

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## ABSTRACT

An improved sediment sampler that is used without winch or wire has been developed, tested, and used at sea. The device employs an expendable iron-ballast, steel-casing combination and a recoverable glass-float, plastic-liner assembly. Of 50 samplers launched in deep water under a variety of conditions, 46 instruments were recovered. Forty-one of these contained samples. The round-trip travel time is less than 15 minutes per 1000 m of depth. The sampler appears to be effective, reliable, and economical in obtaining short sediment cores, often under circumstances beyond the capabilities of existing equipment.

*Introduction.* The literature treating oceanographic instruments contains many descriptions and discussions of measuring and sampling devices that are operated and recovered without the use of wire or winch (Ewing and Vine 1938, Ewing et al. 1946, Wheeler 1941, Van Dorn 1953, Isaacs and Schick 1960, Richardson 1960). The operation of such an unattached instrument involves (i) the launching of an overballasted, deep, submersible float to which the instrument is attached, (ii) the release of the ballast at some predetermined depth, and (iii) the recovery of the pay-load at the surface. Particularly in deep water, unattached instruments can often be operated more effectively and with less difficulty than wire-line instruments, and in some instances they are usable where wire-line instruments are not.

Recently, Moore (1961) solved the problem of withdrawing, with little force, a short core from the bottom, and this made possible the successful development of the free, unattached sediment sampler described and discussed below.

*Description.* Fig. 1 illustrates the final design of the expendable and recoverable parts of the free sediment sampler. In air, without a sample, the sampler weighs 82 kg (the expendable part 71 kg, the recoverable part 11 kg). In

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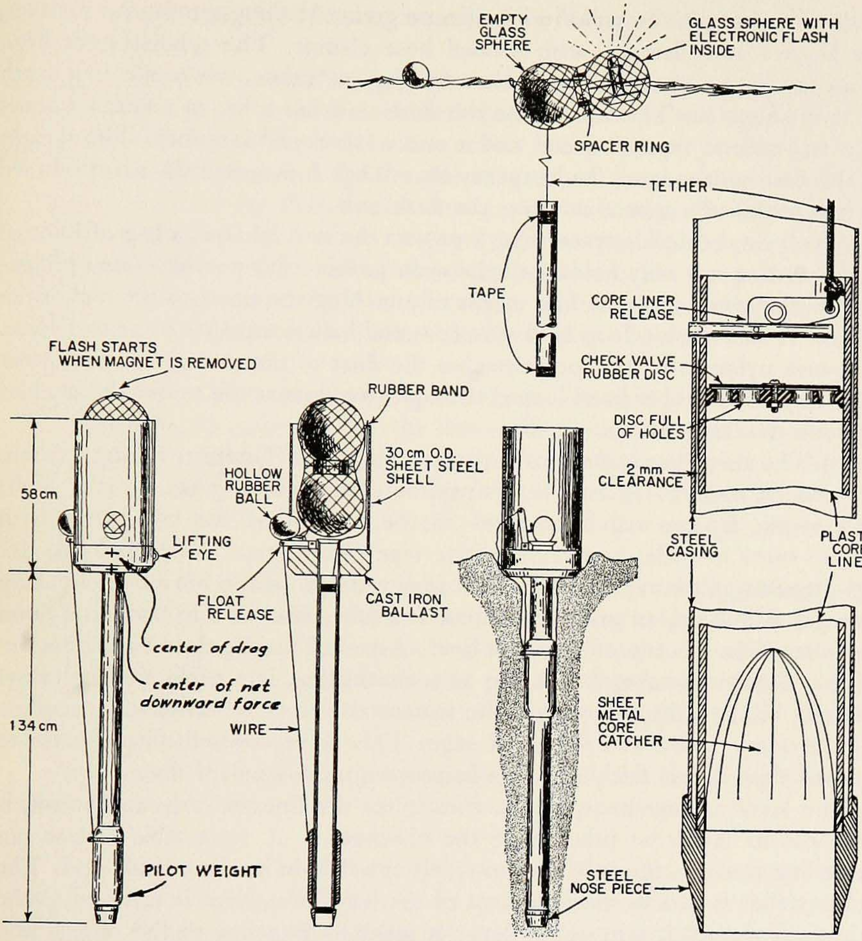


Figure 1. Final design of the unattached sediment sampler consisting of hollow glass-sphere float and cast-iron ballast.

water, when submerged, its total weight is 56 kg, the recoverable part with a buoyancy of 8 kg. The float assembly is slightly buoyant even with one of the two spheres flooded.

The recoverable part is composed of (i) a float, and (ii) the coreliner assembly.

(i) The float consists of two hollow borosilicate glass spheres having an outside diameter of 25 cm and a wall thickness of 0.93 cm. One sphere is empty whereas the other contains an electronic flash unit. The empty sphere weighs 3.5 kg in air, has the hemispheres permanently fused, and has a buoyancy of 5 kg when submerged. The hemispheres of the sphere containing the flash unit, temporarily sealed with silicone grease at the ground-glass surfaces, are aligned and clamped with padded hose clamps. The spheres have been proof tested to pressures of more than 670 kg/cm$^2$; this corresponds to a depth of about 6400 m. The battery for the flash unit has a life of about 16 hours at a two-second repetition rate and a one watt-second intensity. The weight of the flash unit reduces the buoyancy by 1.8 kg. A magnetically actuated reed switch within the sphere activates the flash unit.

A polyvinyl chloride spacer ring separates the two spheres; a bag of knotted nylon netting not only holds the spheres in position but provides some protection to the spheres as well as a means of attaching the floats to the rest of the device. A short nylon loop holds the float and ballast together prior to release. A 3-mm nylon line, 2 m long, attaches the float to the core liner; this tether is coiled, and a rubber band looped through two slots at the top of the sampler prevents fouling.

(ii) The core liner is made of a 122-cm length of Tenite II tubing, 72 mm OD and 65 mm ID. A bronze spring-leaf core catcher (base 15 mm high; 72 mm OD, 65 mm ID) is attached to the bottom of the core liner with several turns of wide, pressure-sensitive tape (Scotch tape, No. Y-9057); this tape, when applied on a dry clean surface, is waterproof and has a high breaking strength. Similarly, an anodized aluminum tube, also 72 mm OD and 65 mm ID, is taped to the top of the core liner. Attached inside, close to the bottom of this aluminum tube, and acting as a checkvalve, is a perforated polyvinyl chloride disc; to the top of this disc is centrally fastened an elastic neoprene disc having a raised and feathered edge. This valve offers little resistance to upward flow and is fairly efficient in preventing downward flow.

The lever arrangement, which constitutes the liner-release mechanism, is mounted in the same tube above the checkvalve. A retractable release pin extending through the tube has an axial-tapped hole in the outside end. The nylon tether is tied to the long arm of the lever, the pivot is fastened to the tube, and the short arm of the lever is pivotally attached to the release pin.

The expendable part of the sampler consists of (i) a ballast, (ii) a casing, and (iii) a float-release assembly.

(i) The ballast is an iron casting, 31 cm diameter, 10 cm high, and beveled at the bottom. A central hole, which receives the casing, is 76 mm diameter.

(ii) The casing, which is 76 mm OD and has a wall thickness of 1.6 mm, passes through the ballast so that 134 cm project below and 5 cm above and is welded in place. A spiral of closely spaced small holes is drilled near the top of the casing; one of these holes is used to engage the pin of the liner release.

The nose of the casing, 64 mm ID and a maximum of 83 mm OD, consists of a conical section that has an angle of 10° with the vertical; these dimensions approximate ideal clearances suggested by Hvorslev and Stetson (1946) for core-tube noses. The nose is chamfered on the inside to guide and center the liner at the bottom of the casing. A 2-mm annulus between liner and casing facilitates passage of in-flowing water, and withdrawal of the liner when the core is taken.

(iii) The float-release lever projects through one of four hand holes cut near the bottom of a sheet-steel shell that is welded to the top of the ballast as protection for the float. A hollow rubber ball is wedged in this hole to hold the release lever down as the sampler is launched. Suspended by a wire from the outer end of the float-release lever, concentric with the core barrel, is a 10-kg streamlined lead pilot weight (114 mm OD, 89 mm ID, and 25 cm in length). This weight, which counteracts the buoyant force of the float as well as the drag of the water as the sampler is descending, maintains the lever in a horizontal position until shortly after bottom contact.

*Assembling.* The core liner, with core catcher and liner release attached, is inserted in the casing so that the liner-release pin is aligned with one of the holes near the top of the casing. A screw threaded into the hole in the end of the pin is used to pull the release pin, thus securing the liner in place. This screw may be left in the pin as a safety measure, but it must be removed prior to launching.

The glass float is slid into the steel shell and the loop on the net bag is slipped over a finger on the float-release lever. The hollow rubber ball is inserted to hold the lever in place. The excess length of nylon tether is coiled and secured to the shell. The electronic flash unit, which is kept inoperative by a magnet secured in the proper position outside the glass sphere, is activated just before launching by removing the magnet.

Assembled in this manner, the sampler is ready for launching and can be stowed conveniently.

*Operation.* Before launching, the electronic flash is turned on by removal of the magnet and the safety screw is removed from the liner-release pin. At a depth of about 10 m, the rubber ball is compressed and floats out; this arms the various releases of the sampler.

As the assembly descends, three forces act upon it: (i) weight at the center of gravity, (ii) buoyancy at the center of buoyancy, and (iii) drag at the center of drag. The weight and buoyancy combine to act at a "center of net downward force." The unit, if dropped horizontally, will soon adjust its attitude so that the center of drag is directly above the center of net downward force (see Fig. 1). Hence, the assembly turns nose downward and descends in a stable attitude.

As the unit accelerates, the drag force increases with the square of the velocity until it equals the net downward force. The maximum velocity, about 450 m/min., remains essentially unchanged, regardless of depth, until the corer strikes bottom. The water drag is also acting on the pilot weight as the corer descends.

At the bottom, as the core barrel enters the sediment, the assembly decelerates. As the pilot weight enters the sediment, drag on it increases, and as the weight slides up the core barrel, it reduces tension on the release wire; the float can now raise the release lever. The loop that restrains the float slips off the hook on the release lever, and the float then rises free of the steel shell. Simultaneously, as the core is forced into the liner, the water in the liner is expelled from the top through the checkvalve.

When the sampler has come to rest, the float is still accelerating upward. The tether between float and core liner, which constitutes a time delay, is pulled free from the rubber band, becomes taut, and pulls on the liner release lever shortly after penetration has ceased. The lever then pivots and pulls the core-liner release pin out of the casing. Now the upward force is transferred to the liner. The static buoyant force of the float plus the force due to its inertia part the core at the bottom, but the core catcher and the action of the checkvalve retain the core.

The speed with which the liner is withdrawn is low because of the resistance of the water that must flow in; as the liner rises, water flows down the narrow annulus between the barrel and the liner. Once free of the barrel, the liner continues to be pulled upward by the float. The recoverable part of the assembly, on reaching the surface, is located by the flash and retrieved.

*Discussion and Conclusions.* Tests in both shallow and deep water as well as the use of the units in sediment-sampling programs of the Scripps Institution of Oceanography, The Woods Hole Oceanographic Institution, and Hudson Laboratories (M. N. A. Peterson and E. L. Winterer, personal communications; V. T. Bowen and P. L. Sachs 1964; R. Bennin, personal communication) have shown that the corer described here is an effective sampler, capable of obtaining good samples economically and reliably (see Table I). Many objectionable features of earlier designs have been eliminated and only a few relatively minor improvements remain to be made.

Compared with conventional wire-line techniques now in use, this model has many advantages. (i) Sampling can be conducted from a large, well-equipped ship, or from a small seaworthy craft without winch or wire, or from a combination of both types of vessels: in good weather, even in the open ocean, a rubber raft could retrieve the samples while the mother ship conducted other operations. (ii) Since this equipment does not require the use of a heavy winch and long wire, the corer is at all times independent of the ship's movement and hence undisturbed during sampling; also, the maximum depth of the station is not limited by the strength of the wire. (iii) Stations can be precisely positioned and closely spaced, even in very deep water. Very little additional time is required to obtain multiple samples, since launching and retrieving times are usually brief, with respect to instrument travel time. (iv) With the unattached sampler, uncertainty about making bottom contact is eliminated, so that an expensive bottom-signaling device is unnecessary. (v) Much higher rates of descent are obtainable; these result in improvement of sample quality and increased core length. (vi) Concurrently, with this method of core sampling, more work in other oceanographic programs can be performed at the same time; for example, an uninterrupted bathymetric traverse can be made while the samplers are being launched.

There are two primary disadvantages in the use of unattached instruments: (i) the bulk and weight required to provide conventional floatation (gasoline), and (ii) the difficulty of locating a small floating object at sea.

(i) When gasoline is used in a deep submersible float to achieve flotation, the ratio of weight in air to buoyancy in salt water is greater than 3:1; and the hazards attending the storage and handling of highly flammable liquid are substantial. The floats employing gasoline are heavy, bulky, and difficult to include in a hydrodynamically efficient package.

(ii) Even simple, passive locating aids such as radar reflectors or flags require additional buoyancy and are difficult to streamline. Active recovery aids such as sonar or radio transmitters, if made small, light, and reliable, soon become very expensive. When equipment is not recovered, there is no way of ascertaining whether it malfunctioned or simply could not be located because of high seas or poor visibility.

The greatest possible streamlining of the equipment is highly desirable, since this provides the fastest rate of descent; not only is greater penetration thus achieved for a given sampler weight, but the sample obtained is in closer proximity to a predetermined position.

Since the bottom-contact release eliminates the need for differing set-ups for varying depths, and also permits a better estimate of the surfacing time, this type of release was chosen over others, such as time-delay releases. The release described here has worked well in sampling sediments with widely varying properties.

Experiments have shown that the force required to free the liner from the casing after a core has been taken is less than 2 kg to rupture the core plus 2 kg to pull the release pin. However, it is essential that the corer enter the sediment vertically, or nearly so, and that it remain vertical. It was found that, if the angle of the corer was greater than 20°, the float was still released but only about half of the liner had been withdrawn; the friction between liner and casing was sufficient to hold the lower part of the liner in the tube.

The ratio of core-tube diameter to length for this sampler is larger than that of most small corers now in use. This results in longer and better cores as discussed and summarized elsewhere by Richards and Keller (1961).

The checkvalve at the top of the liner must be improved so that "washing" of the core during ascent or while sloshing near the surface is completely eliminated. The positively acting valve for gravity corers has made it possible

TABLE I. Results of tests and operational use of 50 unattached samplers. Each bracket in left margin indicates samplers launched sequentially in one series. Under "Weather," those aspects pertinent to ease of launching and recovery are indicated. Instrument travel rates based on shallow water and sonic observations are: falling rate 450 m/min.; rising rate 75 m/min.; round-trip travel time is 15 min. per 1000 m depth.

| Date 1964* | Time: Launch | Sight | Pick-up | Location | Depth m | Core Descr. | Weather | Remarks |
|---|---|---|---|---|---|---|---|---|
| 17/IV | 0153 | 0252 | 0267 | 32°04′N 64°30′W | 4030 | 5 cm silt | Sea state 5; visib. good; overcast | Core washed; round-trip rate >137 m/min. |
| 17/IV | 0410 | 0515 | 0525 | 32°04′N 64°29′W | 4060 | 38 cm silty sand | Sea state 5; visib. good; overcast | Round-trip rate >126 m/min. |
| 16/X | 1840 | 1937 | 2118 | 22°46.9′N 46°02.2′W | 4260 | none | Sea state 2; visib. good; bright moonlight | Valve closed on launching; round-trip rate >150 m/min. |
| 16/X | 1906 | 2000 | 2053 | 22°47.4′N 46°05.1′W | 4310 | 84 cm clay & foram. sand layer | | Round-trip rate >159 m/min. |
| 16/X | 2156 | 2320 | 2325 | 22°45.7′N 46°05.4′W | 4330 | none | | Valve closed on launching; round-trip rate >103 m/min. |
| 16/X | 2205 | — | 2335 | 22°45.3′N 46°06.4′W | 4330 | 98 cm clay & foram. sand layer | | Not near location at surfacing time |
| 16/X | 2217 | — | 2350 | 22°44.7′N 46°07.8′W | 4330 | 92 cm clay & thin foram. sand layer | | Not near ocation at surfacing time |
| 16/X 17/X | 2242 | 2417 | 0017 | 22°45.1′N 46°07.1′W | 4330 | 95 cm clay & thin foram. sand layer | | Round-trip rate >82 m/min.; not near location at surfacing time |
| 18/X | 0322 | 0428 | 0447 | 22°48.6′N 46°59.4′W | 3932 | 95 cm clay & graded foram. sand layer | Sea state 2; visib. good; bright moonlight | Round-trip rate >119 m/min. |
| 18/X | 0340 | 0445 | 0521 | 22°48.7′N | 3781 | 87 cm clay | | Round-trip rate >116 m/min. |
| 18/X | 1205 | 1310 | 1520 | 22°49.9′N 45°03.5′W | 3650 | 88 cm clay, with few foram. sand lenses | Sea state 2; visib. good; daylight | Round-trip rate >111 m/min.; launched while on hydro-station; recovered only by chance |
| 20/X | 0106 | 0200 | 0315 | 22°14.0′N 46°17.0′W | 3800 | 53 cm graded foram. sand & clay | | Round-trip rate >141 m/min. |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 20/X | 0118 | 0210 | 0355 | 22° 14.5′N<br>46° 18.1′W | 3940 | 78 cm clay | | Round-trip rate > 152 m/min. |
| 20/X | 0125 | 0220 | 0410 | 22° 14.8′N<br>46° 18.9′W | 3960 | 78 cm clay | Sea state 3; visib. good; bright moonlight | Round-trip rate > 144 m/min. |
| 20/X | 0132 | 0225 | 0425 | 22° 15.2′N<br>46° 19.7′W | 3960 | 71 cm clay | | Round-trip rate > 150 m/min. |
| 20/X | 0137 | ? | 0435 | 22° 15.4′N<br>46° 20.4′W | 3960 | 61 cm clay | | Not near location at surfacing time |
| 20/X | 0145 | ? | 0450 | 22° 15.7′N<br>46° 21.2′W | 3710 | 96 cm clay | | Not near location at surfacing time |
| 20/X | 1904 | 2000 | 2306 | 22° 20.7′N<br>46° 18.8′W | 3003 | ~ 10 cm friable, consolidated, foram. ooze | Sea state 3; visib. good; bright moonlight | Fractured rock core; made concurrent with rock dredge |
| 20/X<br>21/X | 2338 | ? | 0056 | 22° 19.7′N<br>46° 16.9′W | 3700 | none | | Not near location at surfacing time |
| 20/X<br>21/X | 2347 | ? | 0121 | 22° 18.6′N<br>46° 17.6′W | 3910 | 35 cm clay | | Not near location at surfacing time |
| 20/X<br>21/X | 2353 | ? | 0135 | 22° 17.9′N<br>46° 18.0′W | 3950 | 56 cm clay | Sea state 2; visib. good; bright moonlight | Not near location at surfacing time |
| 21/X | 0002 | — | — | 22° 16.7′N<br>46° 18.5′W | 3950 | none | | Instrument lost |
| 21/X | 0010 | ? | 0205 | 22° 15.7′N<br>46° 19.1′W | 3950 | 73 cm clay | | Not near location at surfacing time |
| 23/X | 2050 | 2215 | 2331 | 19° 29′N<br>48° 21′W | 5140 | 97 cm clay | | Round-trip rate > 121 m/min. |
| 23/X | 2106 | 2237 | 2348 | 19° 28′N<br>58° 19′W | 5450 | 113 cm clay | Sea state 1; visib. good; bright moonlight | Round-trip rate > 120 m/min. |
| 23/X<br>24/X | 2124 | 2248 | 0009 | 19° 26′N<br>58° 20′W | 4920 | 110 cm clay | | Round-trip rate > 117 m/min. |

* Twenty-two unattached samplers were launched near 38°N, 127°W in series of 5, 5, 6, and 6, in the summer of 1964 during the Scripps Institution of Oceanography PIFAN expedition. Of these, all but three instruments were recovered; all those recovered contained sand, silt, and clay cores up to 110 cm long. (Information courtesy of M. N. A. Peterson and E. L. Winterer.)

Two unattached samplers were launched off the Continental Shelf, east of Norfolk, Virginia, in the fall of 1964 from the Hudson Laboratory R. V. SIR HORACE LAMB. Both instruments were recovered; one contained a core. (Information from R. Bennin.)

to obtain good samples of the water-sediment interface (J. C. Burke, in preparation). This valve is held open during descent so that free flow of water through the liner is not obstructed; once the sample has been taken, the valve is seated firmly by spring pressure. This valve has been adapted successfully to the latest samplers used.

The light, small glass float employed in the model described was easily recovered with its sample, and the electronic flash proved very effective at night. From a small vessel, in fairly rough weather, at a range of about 2 km, only one direct flash out of 15 was visible. However, the loom of every flash could be seen, even when waves were breaking over the float. During cruise 44 of the Woods Hole Oceanographic Institution R. V. CHAIN, 22 of the floats were sighted on a bright, moonlit night almost immediately as they surfaced, but one, launched and recovered during daylight hours, was sighted only by chance after it had been abandoned as lost. An active system that would consist of effective and reliable but inexpensive aids for locating samplers and that would operate over a maximum range of 15 km in all weather and visibility conditions would be ideal.

It was found that, at night, in an area of good Loran coverage, under ideal receiving conditions, the drift of the units could be determined. Good fixes, for both the launching and the sighting of each unit, disclosed no measurable change in position. A more precise navigating system would be required to determine lateral motion of the instruments in areas of slow currents.

With minor modifications, the unit described here could be effectively and efficiently used for a number of unattached-instrument operations. The relatively light weight and small size of the float, together with an effective yet inexpensive aid to location at sea, would seem to make it particularly useful for many of the oceanographic tasks suggested by earlier writers.

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