A Multipurpose Large Volume Sea-Water Sampler[1]

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The need for large volumes of sea-water, from all depths, for radioisotope studies with carbon-14, tritium or fission-products, has resulted in the development of a variety of sampling devices. Most of these appear to us to suffer from two serious defects: one, they are clumsy to handle and often require large diameter wire for lowering; and two, they are special-purpose devices giving samples of little value except for a particular analysis. In fact, large volume samples from all depths are also needed for a variety of nonradiochemical purposes: trace element determinations, studies of organic matter, both dissolved and particulate, nutrilite studies of phytoplankton, and others. The device described below has been developed and used with a view to satisfying the disparate requirements of all these programs.

Principle of Operation. This sampler is a modified Kammerer bottle, built of aluminum and stainless steel, Neoprene or Polyethylene valves, and lined with Kel-F plastic. Models of 64 L and of 140 L capacity have been built. Their dimensions are identical except that the smaller has a 10″ diameter sample chamber. The drawings of the 140 L model in Fig. 1 will serve for description of both models.

The sample chamber is an aluminum cylinder, 15″ O.D., and 57 3/4″ long; at each end a 45° neck leads to a six″ opening. The whole inside chamber, and the outside of the valve opening for about 1/2″ are spray-coated with Kel-F plastic (Trifluoro, chloro ethylene polymer). Lugs with 13/16″ diameter holes are welded to the outside of the chamber in three vertical rows, each consisting of three lugs; by means of these the chamber is slipped into position on three rails of 3/4″ diameter stainless steel rods. These rails are then bolted at each end to triangular aluminum plates, making a rigid frame. Between the top plate and the sample chamber is the upper valve plate, which also slides freely on the rails. The sample chamber is connected to each corner of the upper valve plate

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by $14^1/_4''$ lengths of chain. On the lower surface of the upper valve plate and on the upper surface of the bottom plate are neoprene and gum rubber valves, in the form of stoppers, which fit tightly in the 6″ openings of the sample chamber. On the upper surface of the upper valve plate is a catch held in the cocked position by the trigger of the release mechanism on the top plate. Thus, when cocked (Fig. 1 A), the sampler is open, the chamber hanging with its top opening about 7″ below the upper valve, and its bottom opening about 8″ above the bottom valve. When the messenger releases the trigger, both upper valve plate and sample chamber fall free; the inertia of each is sufficient to seat first the lower and then the upper valve, enclosing the sample to be collected.

Construction Details. Blueprints of engineering drawings of the sampler are available on request from the Woods Hole Oceanographic Institution; requests should be addressed to the third author.

Aluminum alloys of high corrosion resistance, like 6061-T6, should be used. It is also important that all moving parts be fitted very loosely, to allow accumulated salt particles to be flushed out easily.

Although handles, as shown in Fig. 1, are a real convenience, they have proved in practice to be quite vulnerable. One sampler, which has now been in use for two years with both handles gone, offers no serious problem in manipulation at sea, so these may be regarded as luxuries.

A small vent tube, $^1/_4''$ I.D., as shown at the top of the sample chamber, is necessary to permit outflow of enough water to allow the valve to seat. This may be a standard one-way pressure relief valve or simply a short open tube; we have used both with no measurable difference in performance. The latter is somewhat more convenient as a point of attachment for an air pump to speed transfer of the water sample to shipping drums on deck.

The release mechanism, a stainless steel trigger (as shown in Fig. 1 A) slotted to permit the wire pennant to pass through it, is hinged on a pin at the bottom of the top plate. On the upper side of the top plate is a loosely attached trigger plate, through which the wire pennant is also passed. After passing through trigger plate, top plate and trigger, the wire is brought around a fixed semi-cylindrical bearing (3″ diameter), looped with a thimble over a $^3/_8''$ aluminum bar on the upper side of the top plate, and fastened with wire clamps. In the cocked position, the trigger engages the U-shaped catch on the upper surface of the upper valve plate. To prevent pre-tripping due to vibration during lowering, it is necessary that the springs (bronze leaf springs) shown holding the trigger forward in the cocked position be relatively strong. To overcome their action, and the frictional resistance of the release, a brass messenger of five pounds weight is needed. The trigger plate simply transfers the weight of the messenger to the trigger, in spite of moderate angular displacement of the wire pennant relative to the sampler.

The upper and lower valves consist of five pieces each: distally, a large spacer of 1/16″ neoprene sheet; next a 1/2″ thick circle of natural rubber gum cemented to a 1/2″ thick circle of neoprene, shaped to fit the 6″ opening of the chamber; finally a Kel-F coated aluminum disk of 5 3/4″ diameter tapped to receive a 3/8″ diameter stainless set screw, which holds the valve to the surface of the plate (see Fig. 1 B) and which can be tightened to compress and expand the valve to compensate for wear in use. When all adjustments are properly made, the water sample comes in contact with only the 6″ diameter ring of neoprene (about 1/4″ wide), left uncovered by the Kel-F coated disk; the foam rubber contacts only the sides of the chamber opening.

The upper valve plate is weighted with three lead cylinders, each of five pounds. This has proved ample mass to seat the valve securely.

The Kel-F coating is applied by a standard commercial process licensed by the M. W. Kellogg Company. A directory of firms equipped to apply this material is obtainable from the Company.

Operation. In Fig. 2 is presented a block diagram of the rigging of the sampler on hydrographic wire. The six-foot pennant of the sampler is fastened through a heavy duty (at least 600 lbs. load) ball-bearing swivel to the end of the hydrographic wire. About six feet above the swivel is rigged a Nansen bottle with both protected and unprotected reversing thermometers. The sampler messenger, fitted with an arm long enough to by-pass the swivel, is hung by a light wire pennant from the Nansen bottle messenger-release mechanism. Tripping at depth is thus managed by first tripping the Nansen bottle, which then trips the sampler. The sample depth is determined from the thermometer readings, and proper operation of the sampler is determined by comparison of salinity between the sampler contents and that of the Nansen bottle.

Aside from the usual spectrum of ills to which a lowered hydrographic device is subject, two other problems are inherent in the design of this sampler:

A surge of the sea surface which meets the sampler when lowered will not fill the chamber fast enough to prevent its floating. In extreme cases this may trip the release—defining the sea-state beyond which work is no longer possible. In less than extreme conditions, the chamber may float up and seat the upper valve firmly enough to suspend the chamber from it; if not noticed, this results in lowering a bell closed at the top and in collecting a sample of surface water only slightly mixed with water from below. This can be completely prevented by clamping to one or two rails, just above the position of the lower lug when cocked, a stop which will not permit the barrel to rise enough to reach the upper valve in the cocked position.

Because of the relatively low mass of the sampler and its high cross-sectional and surface area, the sampler must not be lowered at too high winch speed, otherwise the wire will finally pass the sampler. Using 3/16″ stainless wire, and the 140 L sampler illustrated herewith, a maximum speed of lowering of about

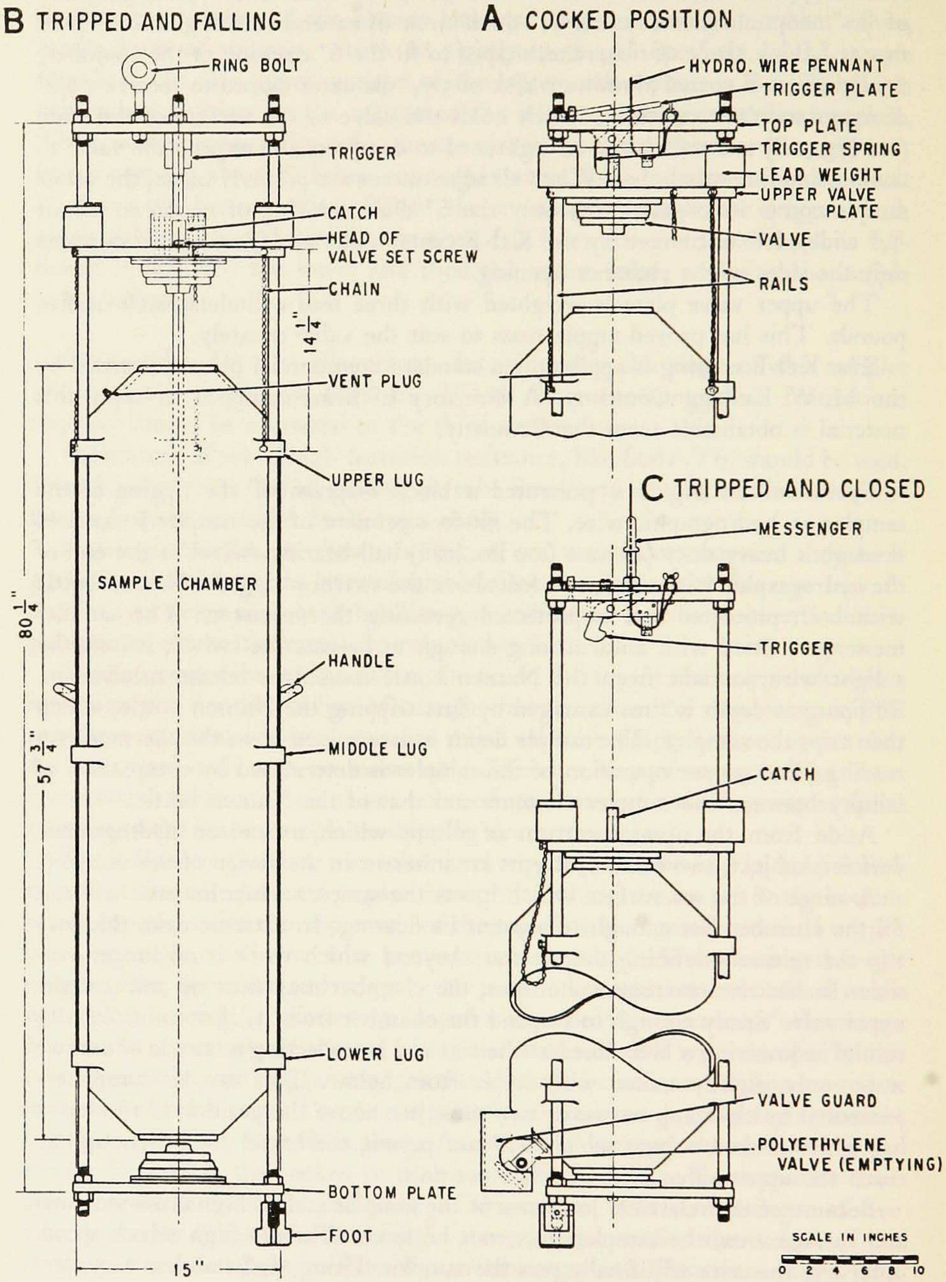
B TRIPPED AND FALLING
RING BOLT
TRIGGER
CATCH
HEAD OF VALVE SET SCREW
CHAIN
14 1/4"
VENT PLUG
UPPER LUG
SAMPLE CHAMBER
80 1/4"
HANDLE
57 3/4"
MIDDLE LUG
LOWER LUG
BOTTOM PLATE
FOOT
15"
A COCKED POSITION
HYDRO. WIRE PENNANT
TRIGGER PLATE
TOP PLATE
TRIGGER SPRING
LEAD WEIGHT
UPPER VALVE PLATE
VALVE
RAILS
C TRIPPED AND CLOSED
MESSENGER
TRIGGER
CATCH
VALVE GUARD
POLYETHYLENE VALVE (EMPTYING)
SCALE IN INCHES
0 2 4 6 8 10

Figure 1.

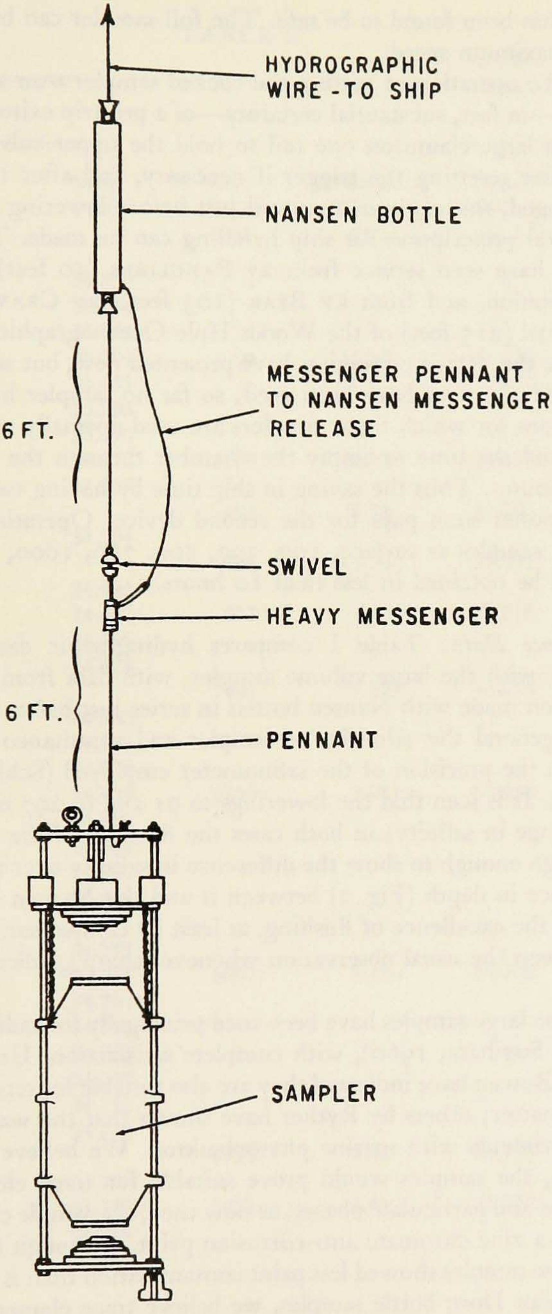
HYDROGRAPHIC
WIRE - TO SHIP
NANSEN BOTTLE
MESSENGER PENNANT
TO NANSEN MESSENGER
RELEASE
6 FT.
SWIVEL
HEAVY MESSENGER
6 FT.
PENNANT
SAMPLER

Figure 2.

45 m/min. has been found to be safe. The full sampler can be raised at normal operating maximum speed.

During the operation of getting the cocked sampler over the side, considerable danger—in fact, substantial certainty—of a pre-trip exists. This is obviated by placing a large clamp on one rail to hold the upper valve plate in cocked position. After resetting the trigger if necessary, and after the Nansen bottle has been rigged, this clamp is removed just before lowering away.

No general prescription for ship handling can be made. The three devices now in use have seen service from RV PANULIRUS (50 feet) of the Bermuda Biological Station, and from RV BEAR (103 feet), RV CRAWFORD (125 feet) and RV CHAIN (215 feet) of the Woods Hole Oceanographic Institution fleet. In each case the details of rigging have presented new, but solvable, problems. Both $5/32$ and $3/16$ wire have been used; so far no sampler has been lost.

The stations for which these samplers are used normally require from 6–11 lowerings, and the time to empty the chamber through the $1/2''$ valve used is about 15 minutes. Thus the saving in ship time by having two samplers in use alternately rather soon pays for the second device. Operating in this way, a station with samples at surface, 100, 300, 500, 700, 1000, 1500, 2500, and 4000 m can be obtained in less than 10 hours.

Performance Data. Table I compares hydrographic data from a recent station made with the large volume sampler, with data from a regular hydrographic station made with Nansen bottles in series just before the large sampler station. In general the salinities of sampler and simultaneous Nansen bottle agree within the precision of the salinometer employed (Schleicher and Bradshaw, 1956). It is seen that the lowerings to 91 and to 297 m spanned regions of rapid change in salinity; in both cases the flushing of the large sampler has been thorough enough to show the difference in salinity over the approximately 5 m difference in depth (Fig. 2) between it and the Nansen bottle. This confirmation of the excellence of flushing, at least by comparison with the Nansen bottle, has been the usual observation whenever sharp gradients have been encountered.

So far these large samples have been used principally for radiochemical studies (Bowen and Sugihara, 1960), with complete satisfaction. Unpublished studies by Curl and Bowen have indicated they are also suitable for separation of organic particulate matter; others by Ryther have shown that the water is suitable for culture experiments with marine phytoplankton. We believe that, with slight modification, the samples would prove suitable for trace element analysis of both dissolved and particulate phases; as now used, the sample chamber is painted outside with a zinc chromate anti-corrosion paint. Although the filtered material from these samples showed less paint contamination than is usual from either Nansen or Van Dorn bottle samples, we believe trace element samples should be collected with an unpainted and probably freshly polished device.

TABLE I.

Cruise CHAIN 17 | Station Number 341
Position: 00° 13′S; 18° 34′W | Date: 24-IV-61

Hydrographic Station			Large Sampler Station			
Corr. Depth (m)	Temp. (°C)	Salin. (‰)	Corr. Depth (m)	Nansen Temp. (°C)	Nansen Salin. (‰)	Sampler Salin. (‰)
1	29.27	35.350	1	–	–	35.008
30	27.13	36.051				
60	20.42	36.241				
99	16.05	35.704	91	15.16	35.596	35.526
149	14.22	35.443				
199	13.21	35.298				
248	12.13	35.170				
298	10.54	34.975	297	10.29	34.954	34.939
398	8.56	34.757				
			494	6.73	34.592	34.590
596	5.47	34.504				
			692	5.16	34.496	34.500
795	4.55	34.495				
994	4.39	34.612	987	4.39	34.616	34.616
1193	4.42	34.786				
1392	4.31	34.924				
			1494	4.07	34.966	34.961
1587	3.98	34.960				
1887	3.46	34.958				
2187	3.298	34.952				
2487	2.971	34.929	2485	2.961	34.933	34.930
2787	2.730	34.916				
3087	2.607	34.903				
3487	2.479	34.896				
3887	2.226	34.879				
4287	1.334	34.778				
4687	1.092	34.749				
5087	1.110	34.746	5003	1.120	34.758	34.754
5378	–	34.754				
5578	1.150	34.750				
5778	1.185	34.748				
6076	1.231	34.748				
6374	1.274	34.753				
6673	1.317	34.748				
			6774	1.33	34.748	34.899
6872	1.344	34.750				
7072	1.377	34.750	7072	1.41	34.750	34.753
7271	1.407	34.746				
7570	1.451	34.746				

Because of the large volume of sample obtained, very little change of temperature occurs during retrieval. Although no advantage has been taken of this fact so far, the samples would be very suitable for collection of living organisms, especially low-temperature stenotherms.

Acknowledgments. It is a pleasure to thank our many co-workers who have assisted in this development, both in making useful design suggestions and in working out safe procedures for ship handling. We are most grateful to personnel of the American Durafilm Company, Newton Lower Falls, Massachusetts, for assistance in technical aspects of the plastic coating. The original development work was supported very largely by the National Science Foundation — International Geophysical Year program. Additional support has been received from the Office of Naval Research and from the Atomic Energy Commission under grant AT(30–1)–2174.

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