Hermetically-sealing Seawater Sampler[1]

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ABSTRACT

This paper describes a device that seals samples of seawater *in situ* in an aluminum or copper tube in millimeter quantities such that the dissolved gases are retained and can be transferred to vacuum systems without either the loss of the contained gases or the introduction of air. The instrument has been tested to depths of 4000 m in the open ocean under modestly harsh conditions.

Recently there has been a resurgence of interest in the assay of dissolved gas concentrations in seawater. Although the analytical problems that have plagued oceanographers have been in part resolved through the use of such instruments as the mass spectrometer and the gas chromatograph, the sampling techniques have been improved very little. The sampling devices that have been employed for the recovery of water samples to be used for dissolved gas analyses offer two potential disadvantages: (i) air may be trapped in the apparatus and retained with the water to be analyzed, and (ii) bubbles may form as a result of vibrations in the hydrographic cable or through a warming of the sample container as it rises through the water colum from oceanic depths, or both. In the case of bubble formation it is very difficult, if not impossible, to obtain a true sample of the original gases dissolved in seawater.

It was highly desirable, therefore, to devise a sampling system such that (i) water can be enclosed in a leak-tight container *in situ*, and (ii) the sample container can be directly adapted to an extraction apparatus. The sampler described here satisfies these two criteria and eliminates the disadvantages of more conventional apparatus.

The construction of the instrument is illustrated in Figs. 1 and 2. A straight aluminum or copper tube (3/8″ OD) is held between two wedge assemblies that close the tube by turning a stainless-steel bolt. The bolts are rotated by two electric motors having a gear ratio of 1570:1 (von Weise Gear Com-

1. Accepted for publication and submitted to press 10 september 1964.

pany, Model VW59, shunt wound). The closing of the wedge assemblies is initiated by the usual messenger, after the sampling apparatus has been lowered on the hydrographic cable to the desired depth.

Details of the electric circuitry are given in Fig. 3. The messenger activates switch S_1 for a time long enough to allow relay R_1 to close. This action starts the motors, which run until the torque as measured by the amount of electric current flowing through the rotor is adequate to guarantee complete closing of the tube. Complete closing in this case means that the thickness of a pinched section of the tube is 0.75 of two times the wall thickness.[2] This current is adjusted by shunts across relays R_2 and R_3. When the proper torque or current is attained, R_2 and R_3 close and R_4 and R_5 are activated, respectively. The closing of R_4 and R_5 shuts off the motors, M_1 and M_2. When the second relay system is activated (R_2–R_4 or R_3–R_5, whichever closes last), the battery is disconnected.

Since the time required to effect closure—about seven minutes—is relatively short, batteries with low capacity can be used (NICAD 2.3 SC, Gould National Batteries, Inc., St. Paul, Minn.).

The entire electrical circuitry is immersed in oil (Penola General Purpose Low-temperature Aircraft Oil, Mel-L-7870A). Since the motors and relays are not affected by high pressures, the apparatus is housed in a rather lightly built box. The hydrostatic pressure is transferred into the container by a flexible neoprene bellows. Oil seals about the motor axles prevent oil leakage. To prevent pretripping of the apparatus, it is important to keep the neoprene bellows elastic at all temperatures and pressures.

The only part of the apparatus that has to be maintained in a pressure-tight container is the battery pack. Since the volume of this power supply is small, it poses no problem.

Aluminum-alloy sampling tubes are generally used because this metal may be pinched together more readily than copper, which always work-hardens and would therefore require more elaborate gear. Since the aluminum does not give a diffusion weld upon closure, as does copper, the water can be released into the extraction system by simply applying force in the opposite direction of the pinch. A disadvantage in using tubing made of aluminum rather than copper is that the stainless steel wedge assemblies must be left on the pinched aluminum tube until the sample is introduced into the extraction system. The sample volume enclosed between the pinches is 5.5 cc.

Carbon brushes employed in the operation of the motors immersed in oil proved to be unsatisfactory—moreso at low pressures (up to about 10 atmospheres) than at higher pressures. However, excellent contacts at all pressures were provided by brushes composed of about 450 single wires of copper 0.2 mm in diameter and held together with a rectangular copper sleeve; these

2. Although the torque required to perform this operation is about three times as high as the maximum torque specified for the gear, no disadvantage has resulted from such overload conditions.

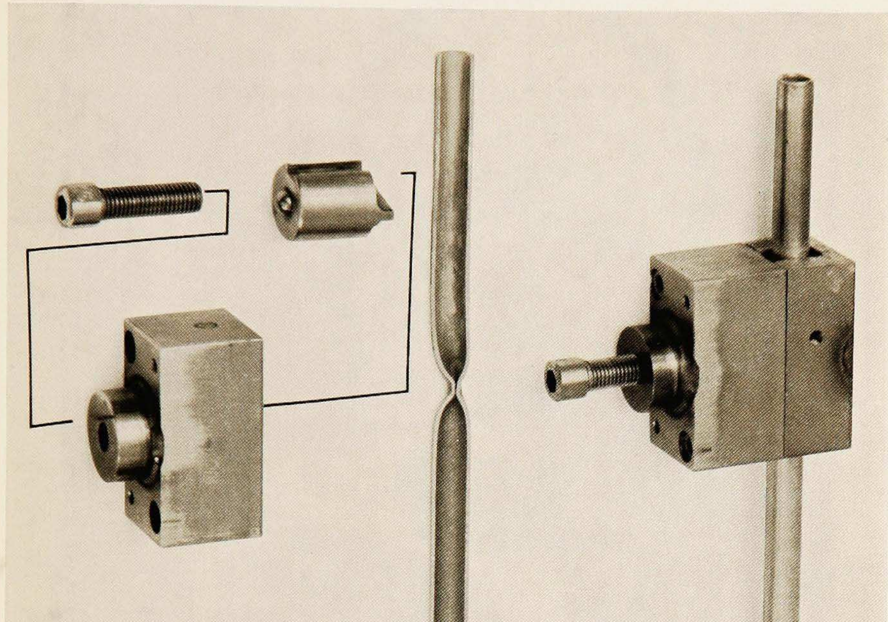

Figure 1. Closing mechanism of the sampler. LEFT: parts of the wedge assembly. CENTER: cross section of a pinched aluminum tube. RIGHT: the sampler and wedge assembly.

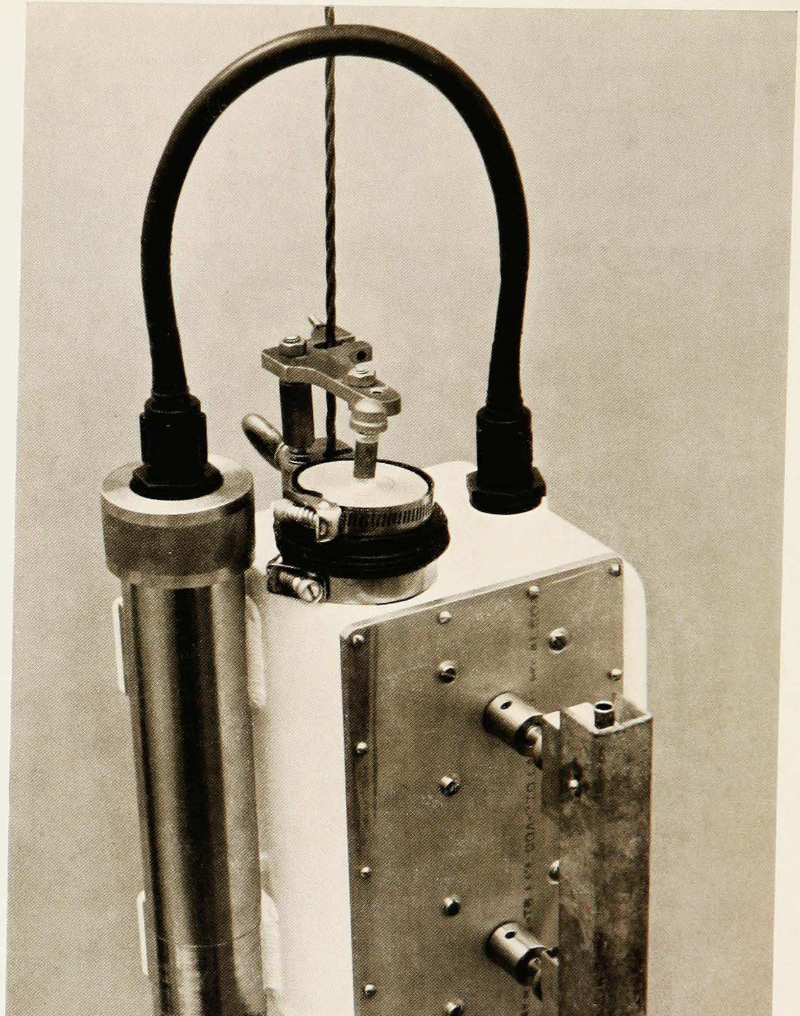

Figure 2. Sampler on the hydrographic cable. The battery pack is at the left, the wedge assembly at the lower right.

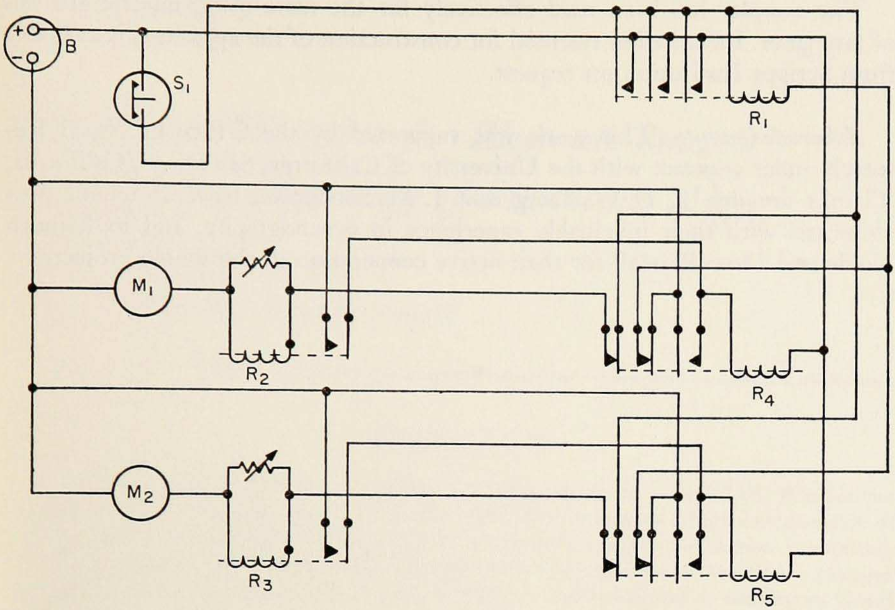

Figure 3. Electric circuit of the water sampler. R_1, R_4, and R_5: Potter and Brumfield KA14AY; R_2 and R_3: Potter and Brummfield MH17-D.

brushes were utilized in the final design. Although the copper brushes wore much faster than their carbon counterparts, excessive wear was no problem because of the short operating time of the motors. To avoid increased wear and burning, care should be taken not to run the motors more than necessary when they are removed from the oil. Outgassing of the oil prior to sealing the housing was found to be important, since this substantially reduces the sparking of the brushes.

The sampler has been tested in Pacific waters to depths of 4000 m and all sample tubes have been recovered in a sealed condition. All operations of the apparatus were satisfactory, even in rather severe seas that produced wire angles up to 52°. After the shunts to relays R_2 and R_3 have been properly adjusted and care is taken to insure that the messenger action upon S_1 is adequate to close relay R_1, no part of the operation seems to be critical. The leakage rate across a pinched section was found to be $< 10^{-12}$ cc/sec, and in our experiment this did not cause any problem.

An extended series of sample collections and tests has shown that a simplified version of this sampler, in which the shunts and relays R_2 to R_5 were left out, is also performing well. In this version, the battery is simply discharged until R_1 falls off. No damage to the battery as a result of the higher discharge rate and time has been detected.

The sampler has been used effectively for the mass-spectrometric analysis of rare gases. Information essential for construction of the apparatus is available from Scripps Institution on request.

Acknowledgments. This work was supported by the Office of Naval Research under contract with the University of California, San Diego, California. Thanks are due E. D. Goldberg and J. M. Snodgrass, both of whom provided me with their invaluable experience in oceanography, and to Minoru Koide and Dave Randall for their active cooperation in the whole project.