[8] "Resolutions and Proceedings of the International Map Committee Assembled in London, 1909," London, 1910, Resolution 6e on p. 4. The wording seems clearly to indicate that 10-, 20-, or 50-meter contour-intervals are meant and not 10-, 20-, or 50-meter contours. The same provision is repeated, slightly more specifically, in the regulations of the second conference (see text below). Hence on our Table 1 three alternative sets of contours between 0 and 100 meters are indicated, namely, 10, 20, 30 meters, etc., 20, 40, 60 meters, etc., and 50 meters. Provision for so small intervals seems reasonable in view of the wide extent of the continental shelf in such areas as the Grand Banks, the North Sea, the Patagonian shelf, the Yellow Sea, the Malayan shelf-sea, and Arafura Sea. On the other hand, this regulation seems to have been interpreted by Stocks [11, pp. 10 and 13] as referring to the contours and not to the intervals, and in this form to have been taken over into his own system. This interpretation has been represented on Table 1. Weight is lent this interpretation by the sheet of conventional signs that accompanies the proceedings of the second conference [9], on which the symbol for auxiliary contours is illustrated by the 10-, 20-, and 50-meter contours in juxtaposition.

[9] "Comptes Rendus des Séances de la Deuxième Conférence Internationale, Carte du Monde au Millionième, Paris, décembre 1913," with separate case of plates, Paris, 1914, Resolution 7f and 7g on p. 112.

[10] "Report of the Meetings of the Commission on the Carte du Monde au Millionième [London 1928]," in "Carte du Monde au Millionième: Rapport de 1928," Bureau Central, Southampton, England, 1929, pp. 4-7, 23-29, and 43-44.

[11] Theodor Stocks, Die Darstellung des Meeres auf der Internationalen Weltkarte 1:1,000,000, Wiss. Veröffentl. Deutsch. Museums für Länderkunde zu Leipzig, New Series, No. 4, 1936, pp. 5-16, with equivalent of sheet South O-26 of the International Map.

Division of Maps and Charts,
The National Archives,
Washington, D. C.

DEEP-SEA MEASUREMENTS WITHOUT WIRES OR CABLES

Maurice Ewing and Allyn Vine

In the deep-sea seismic measurements which were commenced last summer on the Atlantis, the principal problems for which no good solution is in sight are connected with the cable. It seems likely that the best solution is to dispense with the cable altogether.

Figure 1 shows the apparatus as used last year. It consists of a series of bombs, a series of seismographs, and an oscillograph-chamber. The cable leading from the ship to the oscillograph is a wire rope which serves only to lower and hoist the apparatus. It is necessary to place the 600-pound oscillograph-chamber on the bottom of the ocean in such a way that the 4200-foot string of seismographs and bombs shall lead away from it in a line which is very nearly straight. The actual distances from each bomb to each seismograph are determined from the travel-time of the water-wave. Only three tests have been made to date, but it is revealed by the water-waves that the line of instruments did not extend to nearly its full length in any test. In one test the 20-pound bomb was actually less than 600 feet from the oscillograph. Perhaps further practice in the maneuver of laying out the apparatus would overcome this difficulty to some extent, but it will always be difficult to stretch this line out straight without parting it. This is the first problem to be solved.

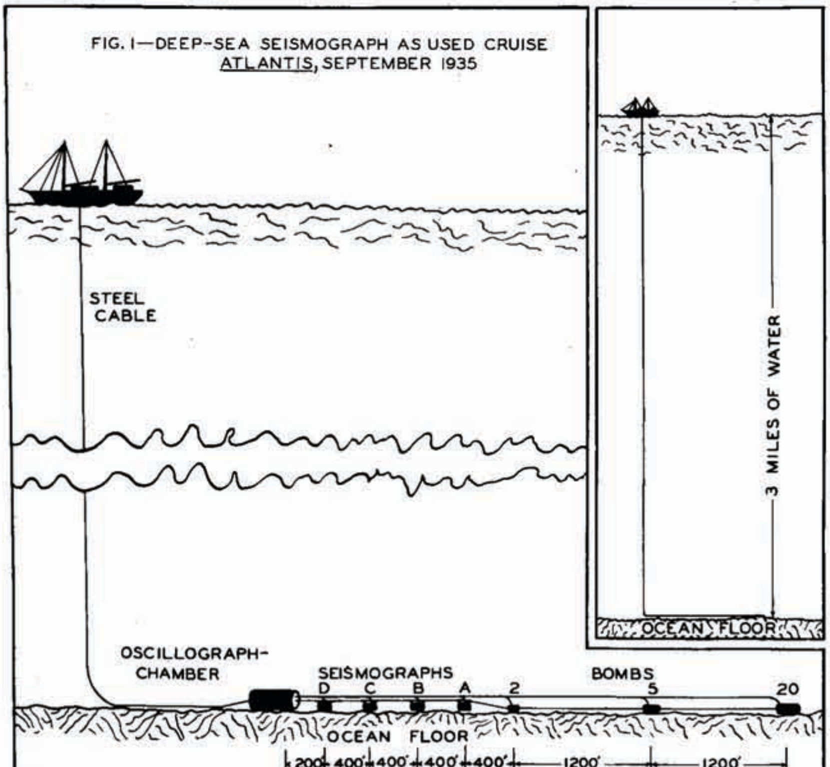
After the apparatus is on the bottom a timing mechanism inside the oscillograph-chamber operates the amplifiers and oscillograph, and detonates the three bombs at intervals of about 90 seconds. During this period it is absolutely essential that no disturbances be transmitted down the cable to disturb the seismographs. To avoid these disturbances it is necessary to pay out an excess of cable, but a slack cable takes kinks when hoisting begins. After three tests the cable showed serious damage from kinks, indicating a short probable life for the cable. Even so, the results of one of the three tests were seriously impaired by disturbances from the roll of the ship which were transmitted down the cable. Elimination of disturbances of cable without incurring serious damage to the cable through kinking is the second problem. Captain N. H. Heck has suggested that the disturbances from roll of the boat may be diminished by a spring-device between the cable and the ship.

It is proposed to solve these two problems by using a float or balloon filled with oil or wax of low density to replace the cable for lowering and hoisting. For several years the authors have been considering the advantages to be gained by using buoyant bodies for lifting apparatus from the depths of the ocean, but no suitable substance for providing the buoyancy suggested itself. The point was discussed with experienced oceanographers who agreed that buoyant devices would be useful, but that most buoyant materials became ineffective at depths. The idea of using oil for buoyancy was suggested by an article in the newspapers of some five or six months ago, in which Professor Picard described a proposed man-carrying bathysphere which would use an oil-filled free balloon instead of cable for support.

In Figure 2 is a schematic diagram of the proposed apparatus. The ballast is sufficiently heavy to take the apparatus to the bottom and the kite gives enough lateral movement to string the apparatus out in a straight line. A small-scale model of the balloon, kite, ballast, and line of apparatus has been built. This model functioned perfectly and laid the string of apparatus out in a straight line on the bottom of the pool in which it was tested. After the apparatus has reached bottom and performed the seismic measurements under the automatic control-system used previously, release of the ballast will permit the balloon to bring the apparatus to the surface.

The problem of locating the apparatus after it has reached the surface is a serious one. A

FIG. 1—DEEP-SEA SEISMOGRAPH AS USED CRUISE ATLANTIS, SEPTEMBER 1935



mast ten or fifteen feet high and a system of signal-emission--either acoustic, radio, or visual--can be provided to aid in finding the balloon.

A large balloon is not required. The weight of the present set of seismic apparatus is excessive and could be reduced greatly should a second set be built. Even so, an oil-filled sphere six feet in diameter would supply ample buoyancy for the present set of equipment. It may be pointed out that the ballast is the only heavy piece of apparatus which rests actually on the bottom, and it is left behind when the apparatus ascends. The danger of the apparatus sticking in the mud is thereby minimized.

The system described above would eliminate the two principal difficulties encountered in the work of last summer. In addition it brings other advantages over operation with cable. If perfected for use in moderate depths, the balloon-system may be used without modification in the very deepest parts of the ocean. Another great advantage is apparent when measurements in the

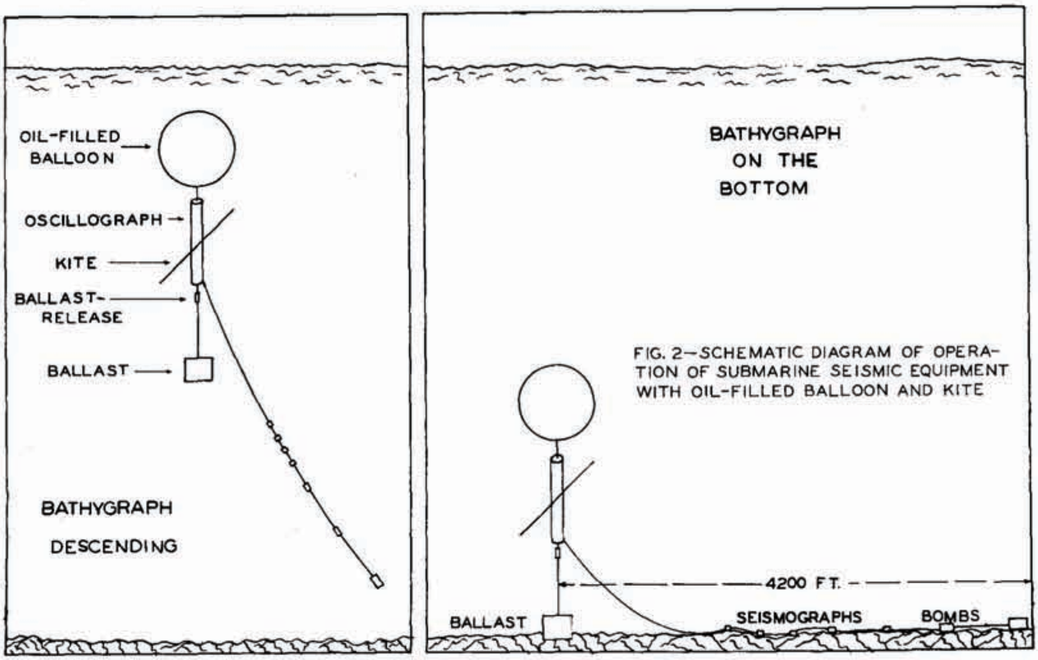


FIG. 2—SCHEMATIC DIAGRAM OF OPERATION OF SUBMARINE SEISMIC EQUIPMENT WITH OIL-FILLED BALLOON AND KITE

Gulf Stream are considered. The current in the Gulf Stream is confined to about 1000-meter depth, and the apparatus would be undisturbed by the current after it had passed this level. With the cable-system it would be very difficult if not impossible to make seismic measurements in the Gulf Stream. This point is of importance because some geologists consider that the value of the eventual seismic results depends to a certain extent upon obtaining a continuous line of measurements from the shore-line outward. To skip 150 miles at a crucial point in the profile, because of trouble with the Gulf Stream currents, is undesirable.

A final advantage of the balloon-system over a cable-system is that it requires much less specialized and expensive equipment on the ship.

Possible use of buoyant devices in other deep-sea measurements

The possibility of replacing wires and cables with buoyant devices in other oceanographic problems seems to be worth consideration. It is possible that these devices may prove as useful in this field of work as sounding balloons have proved in meteorology.

The particular problem which first suggested this method to us--that of submarine seismic measurements--is probably the most difficult of all because of the necessity of using a kite to provide horizontal motion for laying out a line of equipment nearly a mile in length. Where the measuring instrument which is to be sent down is a compact unit, the problem is relatively simple. The following items indicate some of the features which are well within the range of possibility for buoyancy devices. In all of these cases the plans have been formulated in sufficient detail to remove the proposals from the realm of speculation.

(1) Long, undisturbed placement of recording instruments on the bottom--Any recording instrument may be placed on the bottom, left undisturbed for several hours, days, or months, and then be brought to the surface by buoyancy. For example, we may place seismographs at points where earthquake-data are badly needed but islands are absent. Recording current-meters for investigating tidal or other phenomena could also be left undisturbed for a long period of time.

(2) Recall by time-clock or by signal from surface--If an instrument is to remain down for more than a day it would be possible to recall it by means of a signal--say sound-waves--from the surface rather than with a time-clock, in order to avoid danger of surfacing in stormy weather.

(3) Multiple operation--By using several instruments, dropped overboard in sequence, it is

possible to occupy several stations simultaneously. This would be an important advantage in many types of work.

(4) Stations at specified distance or at series of distances above the bottom--By using a reel of piano-wire as the connector between instrument and ballast, and providing the reel with a suitably controlled brake, one or more stops of desired duration may be made on the way to the surface. An instrument held at mid-depth by an anchored buoyant body would be less subject to disturbance than one suspended from a surface-buoy.

(5) Depth unlimited--This device will work in the greatest depths if it will work in moderate depths. It is quite superior to cable-devices in this respect.

(6) Ballast-release by contact with the bottom--For instruments which require no stops during the trip down and back, a ballast-release which functions upon contact with the bottom can be made. A velocity of six to ten knots during descent and ascent can be attained readily, so the round trip would not require an excessive length of time.

(7) Can follow progress down and up by sound-ranging--By causing the apparatus to emit sound-signals at intervals, its progress down and up may be followed by use of sound-ranging hydro-phones. It should be possible to have the ship very near the point where the apparatus comes to the surface, if sound-ranging be employed.

(8) Large initial lifting force can be supplied by a pulley-system--The buoyant scheme would be useful for any case in which part of the apparatus becomes stuck on the ocean-bottom, as, for example, occurs with bottom-samplers. The large initial lifting force can be obtained by having the balloon work through a machine with large mechanical advantage during the first part of its ascent.

Balloons and auxiliary equipment embodying the various features mentioned above will be tested at the earliest possible date, in conjunction with work on the deep-sea seismograph.

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AN INTERNATIONAL PROGRAM FOR COLLECTING SAMPLES OF SURFACE-WATER FROM THE COLUMBIA RIVER TO THE BERING SEA

Phil E. Church

The Oceanographic Laboratories of the University of Washington has enlisted the aid of the Lighthouse Service of Alaska in cooperating in a program for procuring daily temperatures and samples of surface sea-water at the five watched lights along the outside coast of Alaska. At present, surface temperatures and samples are taken daily at Swiftsure and Umatilla, the seaward entrance of the Strait of Juan de Fuca, and the program calls for similar data to be taken at the Columbia River Light Vessel. The Biological Board of Canada has had a similar program in operation for more than three years, daily temperatures and samples being secured at seven lighthouses along the outside of Vancouver Island and the Queen Charlotte Islands. Such close cooperation exists between the Pacific Biological Station and the Oceanographic Laboratories of the University of Washington that this amounts to a unified program for the study of inshore waters from the mouth of the Columbia to the Bering Sea, a distance of 2000 miles.

The procedure requires that the samples and temperature be taken each day at the latter half of the flood-tide at a depth of one meter. At that depth and stage of tide the water is quite representative of surface-conditions. The method is simple and straightforward and involves but little time from the keepers. A two-ounce sample together with its temperature is sufficient.

The instrument to be used by the keepers in Alaska and on the light vessels off the Strait and mouth of the Columbia River was designed at the Oceanographic Laboratories last year and tested at Kingman Reef. It has proved satisfactory in every respect. Essentially it consists of two heavy brass plates, four inches square, which form the top and bottom. Four spring brass rods, 1/4 inch in diameter and about 18 inches long, hold the two ends rigid and act as protectors for the thermometer. A heavy brass tube, 3/4 inch in diameter, which has been milled out over about 12 inches of its length, holds the thermometer. This tube forms the center of the instrument. The thermometer is enclosed within a glass tube which prevents the sea-water