A Recording Ocean Bottom Seismograph[1]

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There has been a long recognized need for reliable seismographs to record earth vibrations on the sea floor [*Ewing and Vine*, 1938; *Ewing et al.*, 1946; *Ewing and Ewing*, 1961]. The success on land of microearthquake studies as a tool in understanding tectonic processes provides fresh impetus to extend these studies to the ocean bottom.

In December 1972 a Lamont-Doherty group tested two prototype pop-up ocean bottom seismometers in and near the mid-Atlantic ridge rift valley in the south Atlantic at about 13°S. The instruments were successfully deployed and recovered nine times, the aim being to evaluate their performance under field conditions. They proved to be a superior tool for seismic refraction studies because of their generally favorable signal/noise ratio and their inherent ability to resolve thin layers. Absolute measurements of earth noise levels obtained on outcropping basalts of the mid-Atlantic ridge proved to be significantly lower than levels recorded elsewhere in areas with thick sedimentary overburdens.

Figure 1 is an outline drawing of the instrument package. The package free-falls with 36 kg of negative buoyancy (drop velocity of 1.7 m/sec), ensuring good coupling with the sea floor. No damage to system components was observed at this impact velocity. At the end of the recording period a timed release mechanism jettisons the footpads and 50-kg lead ballast, allowing the instrument to rise to the surface with about 9 kg of positive buoyancy (rise velocity of 0.55 m/sec). Recovery is aided by the usual combination of flags, radio beacons, flashers, and day-glo paint. The package is light enough (200 kg) to be handled with the ship's hydrographic winch.

The system electronics are housed in a 0.6-meter-diameter aluminum sphere with electrical feed-throughs for external sensors. A crystal-controlled time code generator (TCG) produces a 2-pulse/sec Irig-C format time code, identifying each minute with day, hour, and minute codes. The TCG also supplies a 640-Hz carrier for tape speed compensation. The three data channels (hydrophone and vertical and horizontal seismometers) are preamplified, compressed, frequency-modulated, and recorded on a modified four-channel entertainment-type tape recorder.

The TCG employs very low power drain, integrated (Cos/Mos) logic and draws 25

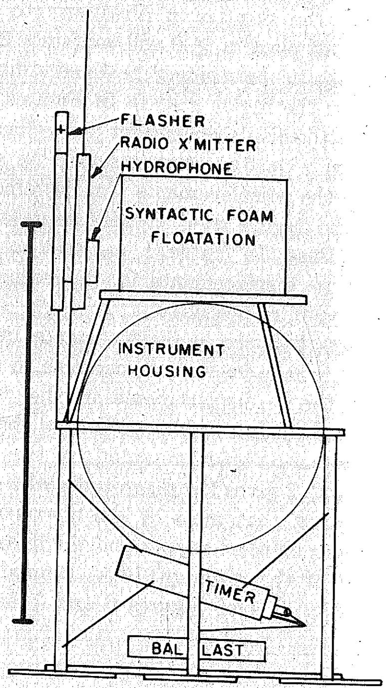

Fig. 1. Line drawing of the physical appearance of the ocean bottom seismograph. Bar at left represents 1 meter. Important subunits are noted.

[1] Lamont-Doherty Geological Observatory contribution 2015.

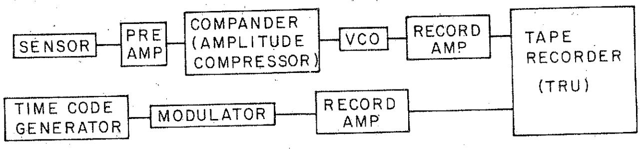

Fig. 2. Block diagram of record system electronics. Only one of three data channels is shown.

ma at 5 volts. The preamplifiers are commercially available integrated-circuit operational amplifiers with a peak to peak input noise of less than 1.0 μv at 10-kΩ source impedance. A bandpass filter from 2 to 120 Hz is incorporated into the preamplifiers. The preamplifiers have selectable gains of +60, 80, and 100 db. The gain compressors are essentially nonlinear nearly logarithmic amplifiers that extend the limited dynamic range of the tape recorder to about 50 db. The frequency modulators have a 680-Hz center frequency with a full-scale deviation of $\pm$40%. The tape recorders were run at 23.8 mm/sec (15/16 in./sec) by using their own internal batteries. Power drain for the whole system is 1.8 watts. See Figure 2 for block diagram.

Power is furnished by rechargeable lead-acid cells. Tape reel capacity and limited battery ouput restricted the operating life of the instrument to just over 12 hours. It is expected that subsequent system improvements will extend this life to about 10 days.

The seismometers are housed within the sphere and are 2-Hz Sprengnether geophones. The system also uses an external hydrophone that is a standard low-frequency pressure-compensated piezoceramic unit. Total system passband is 2–120 Hz.

Although the preliminary field testing of the instrument was primarily an engineering exercise, some useful data were gathered. Several split refraction profiles were shot parallel to topographic lineations on the mid-Atlantic ridge and will be discussed in a later paper. However, we do note that the ocean bottom seismograph's response and generally good signal/noise ratio are such that they should allow long (>100 km) refraction lines to be shot with a minimum of explosives (Figure 3). It is also of interest to note that the level of earth noise is of the order of 10 mμ. The value we obtained on the ridge seems considerably lower than the $\approx$100 mμ obtained by *Francis and Porter* [1972] on the upper portions of the mid-Atlantic ridge at about latitude 45°N. It is not known whether

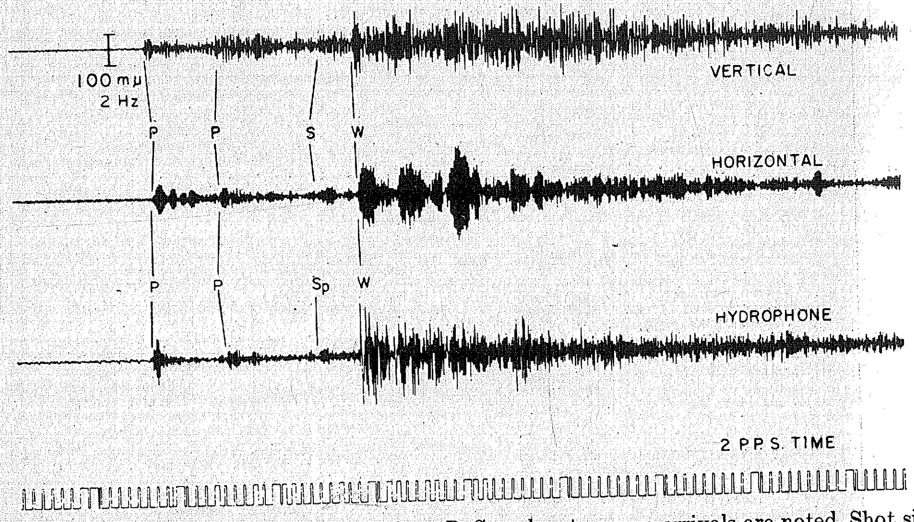

Fig. 3. Typical oscillogram of an explosion; *P*, *S*, and water wave arrivals are noted. Shot size was 1 kg, and range was 35 km. Vertical scale (100 mμ at 2 Hz) is shown at upper left.

our lower value is due to geographical, seasonal, or instrumental variations.

It is reasonable to conclude that there will be a continuing requirement for ocean bottom instruments of this type. Since they can be left unattended in a low-noise environment, they offer a superior means of monitoring small-scale seismicity. They are also well suited to seismic refraction studies because of reduced noise levels and their somewhat better resolution of thin layers over that of surface ships because of shortened ray paths.

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