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ON THE QUESTION OF THE EXCITATION OF ELASTIC OSCILLATIONS DURING DETONATION OF GAS MIXTURES UNDER WATER

(Presented by Academician V. N. Kondrat' ev, 7 VI 1961)

The principal source for exciting elastic waves in marine seismic exploration is explosions of condensed explosives (e.e.) carried out in water. The process is accompanied by the formation of a shock wave propagating through the liquid. The magnitude of the pressure at the front P (in atm), as a function of the charge weight q (in kg) and the distance R (in m), can, in the region of 10–100 charge radii, be calculated from the experimental formula

$$P = A\left(\frac{q^{1/3}}{R}\right)^{\alpha},$$

where A, α are coefficients taking into account the properties of the e.e. and of the water. In order to avoid deterioration of the seismic record due to pulsation of the gas bubble arising during the explosion, the charge is usually placed at a shallow depth, allowing the gases to break through to the surface immediately after the explosion, which leads to underutilization of part of the explosion energy. In the course of work, the magnitudes of the charges vary from a kilogram to tens of kilograms, which is usually sufficient for obtaining high-quality seismograms when conducting exploration by the reflected-wave method under various geological conditions.

For the excitation of elastic oscillations in rock, apparently, it is above all the magnitude of the energy carried by the wave propagating through the liquid that is important, and not the pressure at its front. Moreover, high pressure complicates the conduct of seismic exploration: besides increasing the energy loss during propagation of the wave, it creates around the charge a zone in which living organisms inhabiting bodies of water are affected by the shock wave. The possibilities for regulating the parameters of the shock wave by using various e.e. or by changing the explosion conditions are limited.

Fig. 1. Diagram of the experimental apparatus

Figure 1: Fig. 1. Diagram of the experimental apparatus

The objective of our investigation was an experimental verification of the possibility of using the detonation of gas mixtures, which has been studied in detail in works ([1,2]), for purposes of marine seismic exploration. During detonation of a gas mixture, the pressure at the wave front, owing to the low density of the mixture and the lower detonation velocity, is approximately 4 orders of magnitude lower than during detonation of a condensed e.e. Accordingly, the pressure at the front of the shock wave formed in the liquid will also be considerably lower, while its energy will depend on the energy of the gaseous explosive mixture used. As a result of the reduced pressure at the wave front during detonation of gas mixtures, more favorable conditions are created for preserving living organisms inhabiting the water during marine seismic exploration.

Until now there have been no methods for the technical use of detonation of gas mixtures for marine seismic exploration, and therefore it was advisable to carry out the necessary experiments under real conditions.

The experiments were performed as follows (Fig. 1). Into a steel vessel 1 of volume 230 liters there was fed a gaseous explosive mixture (hydrogen–oxygen or propane–oxygen), the detonation of which was carried out by···

by igniting it in a special device 2. To remove the reaction products remaining after detonation, the apparatus was equipped with an exhaust valve 3. The entire apparatus was mounted on a raft 4. The reflected waves were recorded by means of a piezoelectric sensor on an SS 26-51/D seismic station with various filtering settings. In parallel, under the same conditions, in order to assess the effectiveness of the gas explosion, explosions of concentrated TNT charges of various weights were carried out. The experiments were conducted in the Sea of Azov at a sea depth in the work area of 7–9 m.

Fig. 1. Diagram of the experimental apparatus

A comparison of the seismograms thus obtained showed that the seismic record from the detonation of 230 liters of a propane–oxygen gaseous explosive mixture is equivalent to the record from the explosion of 1 kg of TNT and in some respects surpasses it in quality. The record of reflected waves from the explosion of hydrogen–oxygen mixtures proved to be less intense, which is in satisfactory agreement with the amount of energy released upon detonation of these two mixtures.

Although no special studies of the effect of the explosion on fish were carried out, in the course of work in the vicinity of the apparatus not a single case was observed of dead fish surfacing, whereas nearby, in the zone of TNT-charge blasts, quite a large number of surfaced fish (Black Sea sprat, roach) were observed. The absence of killed fish in the working zone of the apparatus can be

attributed to the low pressure at the wave front during detonation of the gas mixture and, consequently, to such a pressure at the shock-wave front in the liquid as is safe for the living organisms inhabiting bodies of water.

The results of the experiments show that the effect obtained upon detonation of gas mixtures may find technical application in marine seismic exploration, and that the use of gaseous explosive mixtures as an explosive for these purposes may have a number of advantages in comparison with the use of condensed explosives.

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Note: Figure translations are in progress. See original paper for figures.