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Abstract

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MEASUREMENT OF DEEP CURRENTS IN THE BLACK SEA WITH THE AID OF AN ULTRASONIC NEUTRALLY BUOYANT FLOAT

(Presented by Academician V. V. Shuleikin on 17 III 1961)

Up to the present time, statements about the absence of vertical water exchange in the Black Sea have appeared in the foreign literature ([1]). The erroneousness of this opinion was first convincingly demonstrated by V. A. Vodyanitskii ([2]) and then by A. G. Kolesnikov ([3]). The first of them proceeded from the concept of vertical circulation of the waters in the Black Sea, and the second from the concept of turbulent mixing during the motion of waters in horizontal directions, in the system of deep currents.

Not only theoretical interest, but also the demands of practice now compel attention to the question of deep currents: it is necessary to oppose intentions to pollute the Black Sea with wastes from the atomic industry and to reveal the danger presented by radioactive substances owing to the existence of vertical water exchange.

Measurements of the velocities of deep currents by means of recording current meters of the Alekseev system confirmed the existence of substantial currents within the continental slope—from 6 to 20 cm/sec. This is in full agreement with V. V. Shuleikin' s theoretical considerations concerning currents in a nonuniform wind field ([4]). Within the central, halistatic zones, the velocities of currents proved to be about 2-3 cm/sec, and the data obtained using current meters in this range of velocities do not inspire confidence. A more sensitive and accurate method is the method of balanced floats, proposed by the National Institute of Oceanography of England ([5]) and successfully applied in the study of the so-called "Counter-Gulf Stream." In the Black Sea Department of the Marine Hydrophysical Institute of the Academy of Sciences of the USSR this method was improved: the float had an ascent mechanism and a "depth channel," which made it possible to record continuously the depth of immersion.

Fig. 1. General view of the float. *1* –floats, *2* –instrument container, *3* –transmitter, *4* –detachable flange, *5* –radio-wave reflector, *6* –light signal, *7* –antenna.

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The ultrasonic neutral-buoyancy float is a welded hermetic structure made of duralumin tubes, designed for a maximum pressure of 170 atm. The general appearance of the float is shown in Fig. 1.

A rheostat-type depth sensor, changing the time constant of the *RC* circuit of one arm of a multivibrator, makes it possible to control the repetition frequency of the ultrasonic pulses as a function of the depth of immersion of the instrument. An *RC* oscillator, stabilized in frequency and amplitude, generates a carrier frequency equal to 17 kHz. The carrier frequency and the signal repetition-frequency pulses are fed to a pulsed power amplifier supplying the transducer, tuned to a frequency of 17 kHz. A ring barium-titanate transducer was used in the instrument.

To detect the float after it surfaced, it was equipped with a radio transmitter and a light signal that switched on automatically when the instrument rose, as well as with a radar reflector. The apparatus was powered by a battery of cadmium-nickel storage cells, 18 V, 2.25 Ah, which limited the time the instrument could remain on the specified horizon to 2 hours; all the equipment of the ultrasonic float was built on semiconductor triodes.

Balancing of the instrument was carried out in a tank filled with water of known density from the near-surface layer of the sea. The amount of overload required for the float to operate on the investigated horizon was selected by several immersions with successive increases of the load. In this process, information on the depth

Fig. 2. Data on the drift of the ship and the ultrasonic float during determination of the speed and direction of the current

of immersion of the instrument was received continuously by means of the ship' s depth channel. The launch of the ultrasonic neutral-buoyancy float was carried out during the 9th cruise of the expedition vessel *Mikhail Lomonosov* in October 1960. The vessel was drifting near an anchored buoy, which was taken as a reference, relatively fixed point. (Multihour station No. 728 with coordinates $\varphi = 42°59'0$ N and $\lambda = 39°17'3$ E, located at a depth of 2050 m on the eastern periphery of the "halistatic" region of the Black Sea.)

The position of the drifting vessel relative to the buoy was continuously recorded by the shipboard radar station "Neptun." The distance to the float and the bearing to it were continuously recorded by the shipboard echo sounder "Lodar"

Fig. 3. Graph of the course of the ultrasonic marker with depth over time

Figure 2: Fig. 3. Graph of the course of the ultrasonic marker with depth over time

of the Elac firm in echo-ranging mode.

The slant range to the instrument and the bearing to it recorded by the echo sounder, as well as the continuous determination of the ship' s position relative to the anchored buoy, made it possible to construct a diagram of the drift of the float in the horizontal plane (Fig. 2). The path of the drifting ship in the diagram is represented by a solid line with numerical indices from 1 to 12. The trajectory of the float drift is shown by a line with the time indicated from 14 h 21 min to 15 h 27 min; the section of drift during immersion and ascent of the instrument is marked by a dashed line. In an analogous manner, the graph of the float drift in depth with time was reproduced (Fig. 3).

As a result of processing the materials recording the drift of the ultrasonic marker, the following data were obtained on the character of the deep current at the averaged horizon of 750 m: the mean velocity of horizontal water transport was 2 cm/sec, and the flow was directed toward 332°. These data agree well with the results of current recording at this horizon by means of a BPV suspended from an anchored buoy.

In conclusion it should be noted that the measurements of deep currents in the "halistatic" region of the Black Sea presented in this article must be regarded as reconnaissance measurements. In the future it is planned—

Fig. 3. Graph of the course of the ultrasonic marker with depth over time

—to launch several ultrasonic markers of neutral buoyancy simultaneously at different horizons in order to determine the character of layer-by-layer horizontal transport of waters and to ascertain the degree of intensity of vertical exchange in the Black Sea.

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