DEVELOPMENT OF AN UNDERWATER CHERENKOV DETECTOR TO REVEAL SOURCES OF TECHNOGENIC RADIONUCLIDES

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Nowadays for monitoring marine radioactive contamination much use is made of underwater scintillation detectors permitting in situ detection of radionuclides from a surface ship, as well as manned and unmanned submersibles [1]. Detection of gamma-emitting radionuclides using the scintillation underwater detectors presents no special problems. The problem is revealing of nuclides, when their beta decay is not accompanied by gamma radiation. Primarily it concerns the most ecologically significant strontium-90 nuclide. Since no in situ measurement methods for detecting low concentrations of beta emitting nuclides are available, as a rule, laboratory methods of radiochemical sample analysis are employed, being very laborious and time-consuming.

The major difference of the Cherenkov underwater detector (Fig. 1) from a scintillation detector is that its operation does not require a primary transducer (scintillator). Detected particle energy conversion into a light flash occurs directly in sea water (radiator) due to the Cherenkov effect [2]. Consequently, photoreceiver of the underwater Cherenkov detector registers light[1] from radiator of actually infinite volume. The circumstance is of principle importance, as it permits attaining the utmost sensitivity in case of the minimal overall dimensions and weight of detecting equipment.

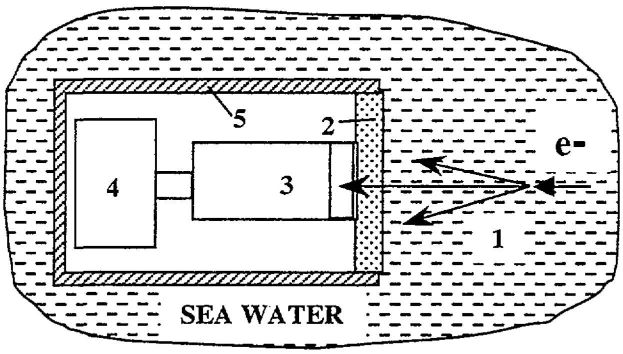

Fig.1 Structural schematic diagram of the underwater Cherenkov detector;
(1) Cherenkov radiation; (2) transparent inlet window; (3) photoreceiver;
(4) electronic module; (5) high-strength capsule.

However, high sensitivity of the Cherenkov radiation underwater detector can only be achieved by suppressing the interfering effect of sea water natural light background. The main components of the light background in sea water are the light of astronomical sources (the Sun, the Moon, the sky and stars), bioluminescence and Cherenkov's radiation emitted by ^{40}K natural radioactive element. The sunlight is the most powerful source in the light background, its intensity in the daytime in near the surface waters exceeding by many orders the Cherenkov radiation level resulting from ^{40}K radiation.

To assure a high sensitivity of underwater Cherenkov detector a method of the light background suppression has been developed based on optical filtration of light fluxes by the wavelength with due regard for differences in spectral characteristics of the Cherenkov radiation and atmospheric light, as well as optimal combination of optical and geometrical parameters of the detector photoreceiver basic components [3]. The spectral sensitivity range of the

[1] for electrons the threshold energy of the Cherenkov radiation in sea water amounts to 0.25 MeV.

Cherenkov detector is concentrated at the band of 220-300 nm *(Fig. 2)*. When passing to the spectrum visible range, the sensitivity decreases abruptly. The sensitivity drop occurs in such a way that atmospheric light flux integral values at the output from the detector can not be distinguished, at the background of statistical fluctuations of the Cherenkov radiation integral values, from the natural potassium-40 radionuclide present in sea water.

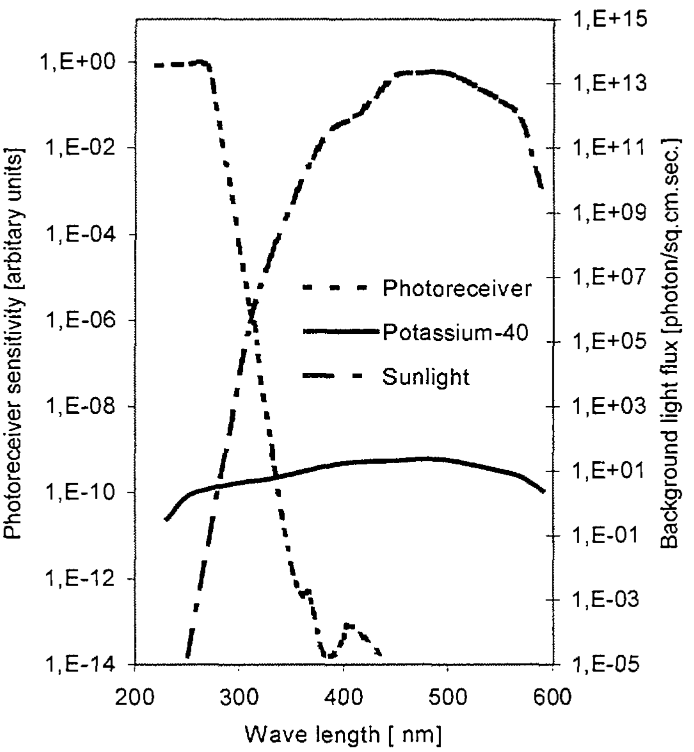

Fig.2 Spectral characteristics of photoreceiver and underwater light background.

Practical implementation of the suggested method, i.e. the light background suppression, is achieved by using a solar-blind filter in the photoreceiver, incorporating an air-isolated alkali metal layer deposited on a transparent substrate in combination with a photoelectric multiplier using either TeCs or TeRb photocathode. Besides, the solar-blind filter contains an additional interference filter made from materials, which are transparent in the working range of the spectrum.

Our estimates and results of preliminary model experiments show that the threshold sensitivity of the detector module for $^{90}Sr + ^{90}Y$ nuclides in near the surface layer of sea water under the most unfavorable conditions will make up approximately 400 Bq/m^3 if the measurement duration is 10 000 s.

References

[1] Proceedings of the Workshop on Monitoring of Nuclear Contamination in Arctic Seas, 18-19 January, NRL/MR/6610-95-7674. Washington, (1995.)

[2] J.V.JELLEY, CHERENKOV RADIATION and its applications, Pergamon Press, New York (1958.)

[3] A.M.CHERNYAEV, A.YU.RUMYANTSEV, I.A.GAPONOV , L.V.LAPUSHKINA et al. Patent RU 2092871. The Bulletin of Discoveries, Inventions and Trade Marks, No 28, 1997.