HYDROACOUSTIC ANTENNA: A POWERFUL TOOL TO FORECAST TSUNAMIGENIC EARTHQUAKES

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ABSTRACT

Hydroacoustic antenna system «AGAM»

In science and technology now and then it happens that the creation of new gadgets, used for measuring and studying common physical phenomena leads to the discovery of new natural phenomena, and as a result, to significant progress in the development of new technical tools.

In the 70s under the leadership of the author, a unique HiFi low-frequency hydroacoustic receiving stationary antenna system was built (Figure 1), which is still being used near the Pacific coast of the Kamchatka Peninsula.

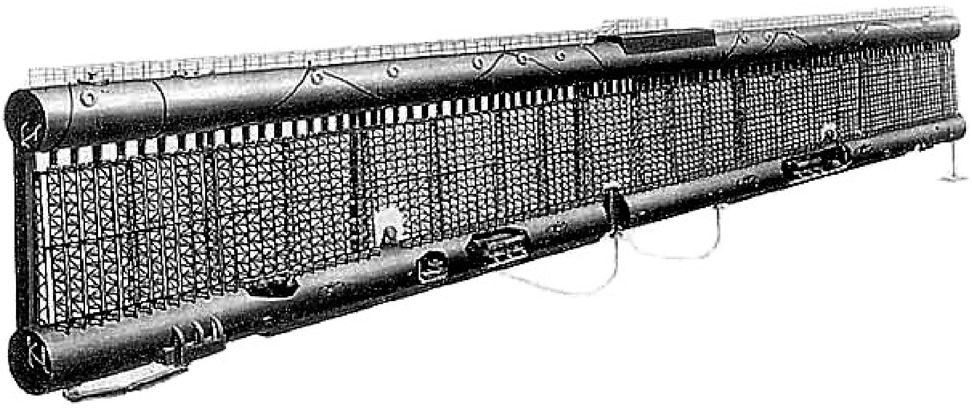

Figure 1. Antenna system «AGAM»

The receiving antenna is a double-row flat discrete-phased array, 750 m^2 (100 m in length and 7.5 m in height). The antenna has 2400 hydrophones located in two planes, 1200 hydrophones in each plane. In order to reduce background noise received from the rear of the antenna, the so-called “electronic screening” method was used instead of traditional screens. The double-row hydrophone array is applied to produce a cardioid-form directivity characteristic, which provided low level of signal reception from the rear side of the antenna. The hydrophones are placed on the main construction, which can be used for towing the antenna to the place of installation, for installing it on the sea bottom, and for keeping the antenna in high working condition under the impact of two-knot currents. The antenna is fixed on the bottom with the help of two anchors weighing 65 tons each. The information, received by the hydrophones, is transmitted (keeping conservation of amplitude-phase ratio between the signals) to coastal stations via special sea-cables. This enables generation of fan-shaped sharp-directed signals in the horizontal plane in the sector $\pm 90°$ from the normal to the plane of the antenna. According to the American classification, this antenna is known as “Cluster lance” (*Foreign…*, 1989-1990). Creation of such an antenna is a very significant achievement, which may be compared with the creation of the radio telescope with the phased array in the form of the cylinder R = 100 m (in 1956) or with the creation of the optical telescope with the mirror ∅ = 6 m (in 1975).

Many years of use of these hydroacoustic receiving antennas demonstrated their significant informative abilities for the large-scale experimental research of various scientific and applied problems of the ocean monitoring. At present, in the framework of “The World Ocean” federal program, in cooperation with the scientists from the Shirshov Institute of Oceanology (Moscow) and Institute of Applied Physics (Nizhny Novgorod), both Russian Academy of Sciences, we are going to use such an antenna to create a new efficient system of observation and storage of geoacoustic information. The parameters of this system will allow us to use the respective data for forecasting underwater earthquakes and tsunamis. As one of the steps in this direction, we are planning to construct an experimental complex for earthquake and tsunami monitoring on the base of a stationary hydroacoustic system of the Russian Navy near the Kamchatka Peninsula.

It is common knowledge that the Earth crustal movements, which cause earthquakes, are accompanied by so-called seismoacoustic emission (*Belyakov*, 1995; *Gavrilov et al.,* 2001). Seismoacoustic signals always coincide with and probably even precede seismic events. *Eiby* (1982) gives an example of unusual behavior of sheep and cows 15 min before the earthquake and explains it by the fact that animals feel some weak deformations of the Earth crust preceding the earthquake, which cannot be felt by human beings. In the classical Japanese literature we can find articles telling us that people were hearing some rumble coming from the ground a few days before the earthquake and explosive noise a few hours before the earthquake. In Garm (Middle Asia) two hours before the 1950 earthquake noticeable oscillations of the ground surface occurred with frequency range up to 500 Hz. *Rikitakae* (1979) emphasized that these oscillations related to the sound-acoustic frequency range could be useful for earthquake prediction.

It is well known that the main reason of tsunamis is underwater earthquakes with relatively shallow epicenters located under the ocean bottom. Seismic activity preceding such earthquakes is accompanied by acoustic waves propagated in water media. These waves can be used as short-time tsunami predictors. From this point of view, the results of the geoacoustic observations in frequency range from 3 Hz to 2 kHz started by the Volcanology Institute (Petropavlovsk-Kamchatsky) on August 2000 (*Gavrilov et al.*, 2001) are of high scientific interest. During the observational period from January 1, 2001 to May 31, 2002 there were 19 earthquakes with magnitude $M \geq 5.0$, epicenter distances up to 480 km, and depths up to 580 km. Before all the earthquakes, except two occurring on the depths > 500 km, there were significant changes in ordinary geoacoustic background noise. These changes were observed from 1 to 20 days before the earthquakes. Beginning January 2002 these results were used for test attempts to predict earthquakes.

Taking into account that the propagation conditions of geoacoustic signals in water media are much more favorable than in the Earth crust, we can expect better results based on the hydroacoustic stationary antennas. This supposition is supported by the encouraging results of the Earth tectonic investigations made by American scientists in 1993. They used the SOSUS hydroacoustic antennas and recorded twice as many earthquakes than the seismographs of the World standard seismic net. Since hydroacoustic signals generated by seismic oscillations were recorded on the outlets of directivity characteristics, it was possible to improve the signal/noise ratio significantly. Also, a number of spatially distributed antennas allowed accurate localizing on the sources of the earthquakes (epicenters). Taking into account that the efficiency of the Russian Navy receiving hydroacoustic antenna (Figure 1) is considerably higher than that of the SOSUS system, the results of monitoring earthquakes and associated tsunamis should also be higher.

The major problem in realizing this project is poor financing. Not only Russian Federation, but also many countries are interested in earthquake and tsunami prediction. Therefore, one of the main purposes of the present paper is to attract attention of the world scientific community to this problem in the hope of finding international financial support and to use this Russian experimental base together with other countries.

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