Hydroacoustics: What is it?

M. V. ZHURKOVICH

Sound vibrations in air have always accompanied man in his interaction with the surrounding world and helped reveal to him its full diversity and beauty. The situation is similar for man on the solid ground or on the water's surface. But what happens under the water?

Legends say that in the olden days fishermen listened to the sounds produced by fish and sea animals using the fact that water is a good conductor of sound. How did they do that? Leonardo da Vinci (15th century) gave an answer: "If you stop your ship and dip one end of a long pipe in water, you will hear the noise of ships at a large distance."

Before the modern era, ideas were proposed, among others, to use sound echoes in water to measure sea depths and to ensure the safe navigation in regions of drifting icebergs. While some work was done on underwater communication, in the majority of cases these ideas remained unclaimed and awaited the future for their practical implementation.

The need to create a means to "hear" and "see" underwater became quite pressing during World War I. The Allies suffered heavy losses at sea from attacks by German submarines and this stimulated the search for technical means of detecting submerged vessels and stopping their activity.

The best minds worked on this problem and a solution was finally found! The French scientist P. Langevin designed a powerful (for that time) electroacoustic projector and the Russian engineer K. V. Shilovsky designed a sonar.

The further development of hydroacoustic science and technology was driven by the need to solve tasks and to meet requirements set by the Navy. The "marriage" of a sonar transducer and a vacuum tube gave

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birth to a range of instruments very much needed at sea: passive sonars (detectors of objects based on the noise they emit), echo-ranging sonars (detectors of the signals reflected from objects), underwater communication devices, and depth measuring instruments (echo sounders). Underwater sound beacons and a host of other instruments to study the ocean may also be included in this list.

World War II, particularly the Great Patriotic War, once more confirmed the vital necessity of using hydroacoustics to successfully fight submarines and brought about significant expansion in the scope of problems solved by institutions devoted to hydroacoustics. Hydroacoustic equipment was involved in mine control, in operating torpedo automatic guidance systems, and in a wide range of other tasks.

The application of hydroacoustic systems would have been much easier if the sea and ocean media were homogeneous. In reality this is far from the case. The characteristics of sound propagation in aqueous medium, in whose structure are found boundaries and varying-temperature layers and where variations in internal structure result in multipath propagation effects, refraction, scattering, attenuation, and interference, have been and continue to be a subject of investigation by numerous researchers. The achievements in this field have ensured further progress in the creation, application, and proper operation of hydroacoustic systems.

Sonar systems of the last few decades are capable of detecting and identifying targets and determining bearings and ranges at distances up to several hundred kilometers. Truly, they have become our ears, eyes, and brains in estimating the surface and interior condition of the ocean and have given answers to the questions of what, where, when, and how.

This progress has become possible through the efforts and talents of designers of such sonar equipment as transducers, receiving and radiating antennas, multichannel (up to 3000–5000 channels) equipment to receive primary and secondary (logical) information and for processing and displaying this information, and, without question, computers. Also the progress was to a great extent due to the achievements in investigating the hydroacoustic characteristics of the oceanic medium and a revolution in the area of suppression of the interference of a vessel's own acoustic and electronic noise with performance of the hydroacoustic equipment it carries.

As a result, today hydroacoustic systems solve the same set of problems in the ocean as those solved by radar, radio communication, and radio navigation systems in the atmosphere and determine to a great extent the combat effectiveness of the Navy.

But that is not all!

In the late 1940s and early 1950s, there rose a pressing need for improving the effectiveness of the fishing fleet. Again, a solution to the problem was found based on hydroacoustics. In the early 1950s, an independent branch of hydroacoustic engineering called fish echolocation developed. We cannot but note here that the earlier attempts at fish echolocation with the use of ship-borne echo sounders had been made in the late 1920s to early 1930s. Today, it is difficult to find a fishing boat that does not have hydroacoustic fish-finding equipment. The variety of this equipment allows one to not only search and locate fish but also to identify species, determine the size of a school, automatically search for fish and track them, maintain control over trawl filling and, most important, guide the ship during the process of searching and fishing. Specialists from different countries have concluded that the size of the catch of fish and other marine life is in direct proportion to the number and quality of the ship-borne hydroacoustic equipment in the fishing fleet.

In the 1970s, world economics called for shifting the areas of exploration for oil and ore deposits toward the deep-water shelf of coastal seas thereby requiring better knowledge of seas, oceans, and continental shelves. As a result, new systems of underwater position-finding based on hydroacoustic techniques were added to the traditional suite of hydrographic equipment. This new class of systems provided opportunities for detailed surveying of the seabed prior to the erection of oil drilling platforms, the laying of pipelines and their inspection and repair, collection of data for deep-sea mineral resources production, examination of underwater structures, and erection of oil platforms in the open sea. Further opportunities are the guarding of ocean constructions from the unauthorized approach by underwater vehicles, swimmers, and divers, automatic repairing of drilling ships and keeping semi-submerged platforms at a preset point in deep water without anchors and in any weather, locating a deep-water borehole and inserting a drilling tool into it, providing wireless communication with self-contained autonomous underwater vehicles, and many other activities.

From the 1960s to the 1980s, the ideas and principles of hydroacoustic engineering were directed toward the needs of the health service. New methods of gathering objective information about the state of internal human organs were needed; methods that did not injure the patient or inconvenience either the patient or the doctor. Considering the fact that the human body is 80% water, the achievements in the design of high-frequency hydrophone transducers, antennas, and other instruments provided opportunities to solve many problems by means of hydroacoustics. Today, ultrasonic instruments are used in obstetrics, ophthalmology, the examination of internal and external organs, cardiology, neurology, and many other branches of medicine.

It should also be noted that the appearance in recent years of pleasure submarines would have been impossible if it were not for hydroacoustic observational equipment that ensures safe navigation.

Though hydroacoustics was born because of military requirements, today it contributes to the prosperity of human society and the interaction between man and nature. This book deals mainly with the development of military hydroacoustics in this country. It includes reminiscences by people who dedicated their lives to this area of science and technology. However, the history of Russian underwater acoustics, as an important component of the natural sciences and engineering and with its close connections to a number of other branches of science and technology, will continue to be the subject of further investigations and publications.