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About INFLUENCING LARGE-SCALE STRUCTURE of FLOATING BUBBLE STRATUMS ON the STATISTICAL PROPERTIES of SCATTERED SIGNALS

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In this paper the results of model experiments dedicated to investigation of direct scattering and backscattering of sound signals on the thin random bubble screen are shown. On measuring the medial intensity of scattered signals the information on the average concentration of resonans bubbles is obtained. The finding of cross correlation radius of a scattering field amplitude has allowed to estimate correlation gauges of inhomogeneities in a bubble stratum .Thus, passing through a stratum the acoustic wave bears the information on the medial distance between groups floating bubble, while on correlation curves of backscattering it was possible to judge the sizes of bubble aggregations.

The purpose of the given paper was the experimental study of amplitude properties of an acoustic wave, scattered on the thin random screen of propellented gas bubbles in water. Both direct scattering, and backscattering were explored. The estimates of the medium-sizes of bubble groups and of medial distance between them were obtained by results of measurings correlation gauges of a dispelled sound wave .

Earlier in paper [1] the radii of a correlation of the amplitude an acoustic wave passing through a bubble stratum were investigated at different distances from a stratum up to view point. As radius of a correlation of a signal amplitude was maintained at removal of the receiver from an explored stratum, a conclusion about large-scale of inhomogeneities on the screen as contrasted to by wave length was drawn . It testified to existence of collective effects of scattering, as diameter of a separate resonans bubble was much less than a wave length.

However, spatial radius of a correlation of a positional relationship of inhomogeneities, estimated on time of a correlation of amplitude of signal scattered forward, can feature both medial distance between groups, and sizes of the bubble aggregations. As the obtained experimental results on measuring cross radius of a correlation of a wave amplitude, passing through a lamina floating bubble screen, have not allowed uniquely to decide an inverse problem of acoustics - to determine the medial size of groups of floating bubbles under the data of ultrasonic measurings, it is represented expedient to analyze correlation properties of backscattered signal. In this case the absence of a forward signal allows uniquely to explain appearance of a correlation in a scattered field. Cross radius of a correlation can not be bound to bands of a coherence any more, that is feature medial distance between separate bubbles or groups of bubbles, as at forward scattering. The availability of correlation gauges of amplitude of backscattered wave can be explained only by correlation in a positional relationship of bubbles.

For checkout of this guess some series of experiments on study signals, both direct and back scattered on a stratum at miscellaneous values of a current intencity of an electrolysis on the generator of bubbles, defining medial concentration of scatterers in a stratum, were done. It has allowed to determine the medial size of groups of floating bubbles, and also the medial distance between them.

For realization of model investigations the experimental plant was built, the flow chart of which one is given in the fig. 1. The radio-pulse signal formatived of a signal of the generator (1) by the modulator (3), through a power amplifier (4) acts on an ultrasonic radiator (10). The radiated signal is scattered by a bubble stratum (14), which one is formed by the block of an electrolysis (12), and amount of bubble generated by it is proportional to current of an electrolysis. Backscattered signal receives by a hydrophone (11), arranged near the source (10), and signal scatterd forward - by hydrophone (13), taking

place for a bubble stratum. The received signal strengthens by the amplifier (6) and for eduction of an amplitude is detected by a square-law detector (7). Then the signal subjects to digitization by an analog-digital converter (8) and acts on a computer (9) for further handling. The pulse generator (2) determines parameters of impulses of radiation and it is used for sync of an analog-digital converter by an adjustable line of delay (5).

For investigation of backscattering the frequency of a sounding signal made 100 kHz (for matching with results of paper [1]) and 375 kHz (as in this gamut backscattering is more intensive). The source was lowered in hydrodynamic basin on the depth of 1 m, the receiver was immersed on 1,1 m. The bubble stratum was in a band of Fraunhofer of the source, the distance between them was L = 3,1 m . The receiver was placed on the end of a boom of length L0 = 2,2 m which was hard-mounted by the other end at the centre of a stratum, the receiver could freely move on a circle at rotational displacement of a boom in a horizontal plane (fig. 2). Some fares on an arc of a circle from a point I up to a point III were accomplished at miscellaneous quantity of a current intensity of an electrolysis. The obtained diagrams of scattering have shown an isotropy of scattering, that confirms an equitability of bubbles in a stratum, and therefore, a validity of approach of the boundless random screen of scatterers.

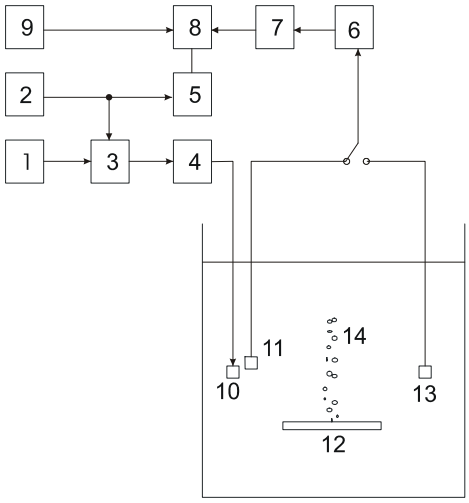

Fig. 1. The flow chart of the experimental plant.

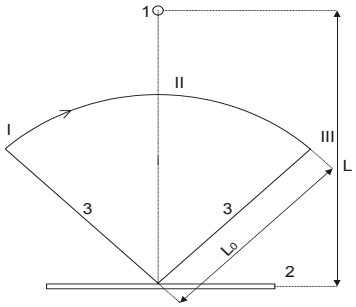

Fig. 2. Geometry of experiment:
a backscattering, dorsal view.
1- source, 2-bubble stratum,
3- boom with the receiver, anchored on the end.

Then in points I and II (fig. 2) for a backscattering, and also at scattering forward, the recording of a signal amplitude was conducted at a current of an electrolysis J=1, 2, 3, 4 A. The concentration of inhomogeneities varied directly to a current intensity of an electrolysis on the generator of bubbles, that is demonstrated by observed data of intensity of an acoustic wave, passing across a bubble stratum. In fig.3 they are shown for a case of a backscattering at radiated frequencies 100 and 375 kHz (curves 1 and 2 accordingly). The normalization of intensity on maximum rating for each curve was done separately. The medial intensity of a backscattering grows with magnification of a current intensity, that confirms increase of concentration of scatterers in accordance to magnification of a current intensity of an electrolysis. The similar effect is obtained and for a case of reception of a signal passing across a bubble stratum at an

arrangement of point of view not on an axis of the source. At the same time the intensity of a signal scattered forward (fig. 4) exponentially wanes with magnification of a current intensity, that confirms monotonic linear increase of concentration of scatterers with magnification of a current of an electrolysis.

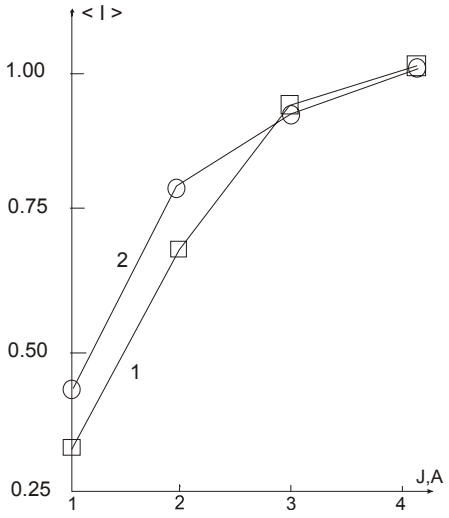

Fig. 3. Medial intensity of backscattering: 1- f=100kHz, 2- f=375kHz.

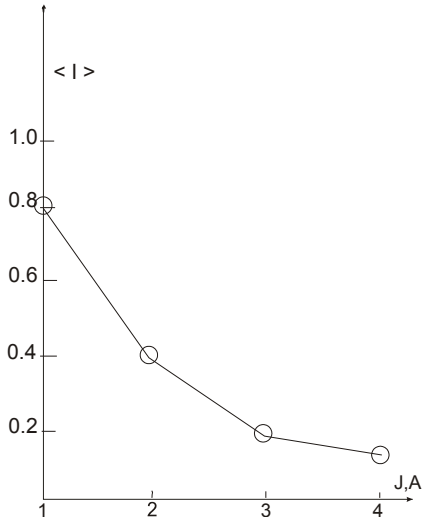

Fig. 4. Medial intensity of acoustic field behind the screen, normalized on intensity of waves in absence of bubble stratum.

The procedure of finding of cross radius of an amplitude correlation was encompassed by multiplication of the correlation time retrieved experimentally - τ_0 (it is time of an amplitude correlation coefficient decrease) on the mean speed of emersion of resonant bubbles to a surface: : $\rho_0=V\tau_0$. As resonant radius of a bubble has the order of 10^{-3} mm, emersion speed counted on the model formula, debated in paper [2] will be small, and the bubble of such a size will be moving to a surface for some hours, that is not confirmed by experimental observations. Therefore, it is necessary to suppose, that the bubbles should float to a basin surface by groups, the velocity which one is much higher than the velocity of resonant bubble, being taken separately. Agrees [3], speed of emersion of bubbles at the count of collective effects of scattering for frequency f=375 kHz makes about 1,5 cm /s.

The investigations of cross radius of a correlation of amplitude of a sound wave backscattered on a bubble stratum have shown that at miscellaneous currents of an electrolysis the radii of a correlation are approximately identical. In fig. 5 the radii of correlation of amplitude of backscattered signal for frequency f=375 κHz (curve 1) are given; and also in case of reception of an acoustic wave scattered on the random screen in a point removed from an axis of a source (a curve 2). The similar situation can be also observed at frequency f=100 kHz .

However, at measuring amplitude of a signal, passing across a bubble stratum, radius of a correlation of a scattered field decreases in accordance with magnification of a current intensity of an electrolysis (curve 3). Therefore, it is reasonable to suggest, that radius of a correlation of amplitude of a signal passing through the random screen features distance between groups of floating bubbles: the more the current of an electrolysis, i.e. more bubbles concentration, the less the distance between their aggregations. While radius of a correlation of backscattered signal describes the sizes of these groups,

which do not depend on a current intensity of an electrolysis. Really, allocation of bubbles on the sizes is uniform and does not depend on concentration [3], therefore, groups can be formed of approximately identical quantity of bubbles and on the average have the same gauges for miscellaneous concentrations, that is for miscellaneous values of a current of an electrolysis. But in the case of reception of the passed signal in a point arranged not on an emitter axis, the dependence observed is similar to the one obtained at backscattering, as the receiver does not hit in the sounded area, the forward signal misses, and cross radius of a correlation can not be interlinked to bands of a coherence, and, therefore, it features the medial sizes of bubbles aggregations.

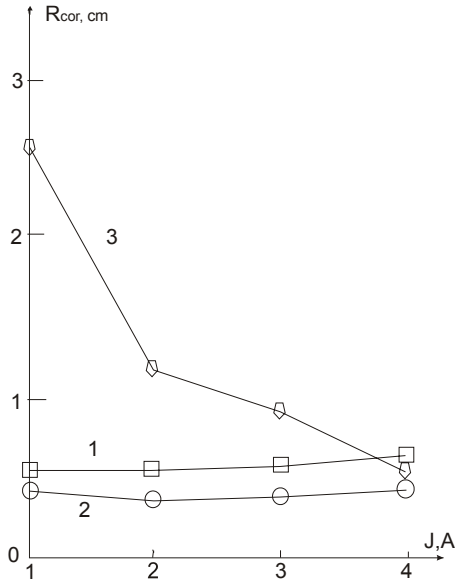

Fig. 5. Radii of a correlation of amplitude at a radiated frequency 375 kHz for backscattering (1), scattering sideways (2) and scattering forward (3).

Thus, for definition of the properties of distribution of bubbles in a thin layer, coming to the surface, by remote ultrasonic methods it is expediently to use both direct, and backscattering of sounding signals. Thus, passing across a stratum the acoustic wave bears the information on medial distance between groups floating bubbles, while on correlation gauges of a backscattering it is possible to estimate the sizes of the aggregations.

This work was supported by the Russian Foundation for Basic Research (project № 01-02-17653) and the Competition Center of Basic Natural Science (project E02-3.5-517).

R E F E R E N C E S

1. Gryaznova I.Yu., Kurin V.V., Kustov L.M., Tyurina O.A. Experimental research of correlation gauges of a sound wave, passing through a random bubble screen // Acoust.J. 1998. V.44. №1. 64-67 pp.
2. Yezersky A.B., Sandler B.M., Selivanovsky D.A. Sonar observation of gas bubbles near to a marine surface // Acoust.J. 1989. V.35. №5. 829-834 pp.
3. Gurbatov S.N., Kustov L.M. Echo sounding of non-stationary floating bubble stratums // Acoust.J. 1990. V.36. №2. 262-268 pp