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INVESTIGATION OF NON-LINEAR PARAMETRIC SOUND RECEPTION

V.I. TIMOSHENKO - V.A. VORONIN - V.N. MAKSIMOV

Résumé. - L'article présente les résultats d'une recherche expérimentale concernant un récepteur acoustique non linéaire paramétrique dans la bande de fréquence 10 à 20 kHz. On donne également le schéma de principe d'un dispositif qui a été développé ; celui-ci est le complément à un ensemble de dispositifs d'émission paramétrique.

Abstract. - The paper presents the results of an experimental research of nonlinear parametric sound receiver in the frequency range of 10-20000 c.p.s. The structural scheme of a developed arrangement is given as well. The arrangement is an additional part to a set of arrangement of parametric sound radiator.

In receiving-radiating non-linear parametric acoustic systems creation of directional reception using the non-linear parametric sound reception makes contribution to the advantages of non-linear radiator /1/ (band width, small size of a transducer, a narrow directional diagram in a broad band, deficiency of side lobes).

The theory of parametric sound receivers was developed in the works suggested by P.Y. Westerwelt /1/, H.O. Berktay /2/, Y.Y. Truchard /3,4/, V.A. Zverev and A.I. Kalachev and others /5/.

The interaction of pumping wave and a sound wave in the parametric sound receivers occurs in the medium under their mutual propagation. Interacting with a powerful pumping wave, the sound wave received modulates the former. Recording and processing of the modulated pumping wave gives possibility to define the parameters of the low-frequency received signal. Separation of the energy transformer from the transformation space of the signal spectrum gives a number of technical advantages of parametric sound receivers application over the traditional ones. Unlike the radiator /6/ frequencies of the interacting waves in the parametric receiver differ greatly. Besides, the wave vectors of the interacting waves may be non-collinear.

To calculate the characteristics of parametric receivers one can use the solution method of hydrodynamic non-linear equations. The paper presents the results of the experimental investigation of the non-linear parametric sound receiver model. The device created is an addition to the set of parametric acoustical radiators /6-8/.

In most publications on parametric receivers the information about the received low-frequency signal is singled out by means of spectrum component processing of the sum and difference frequencies. The low-frequency audible signal in the created device is detected by the momentary variation of the pumping wave phase, since the signal singled out by the receiving transformer and created as a result of low-frequency received signal interaction with pumping wave may be represented as a phase-modulated pumping wave by a low-frequency signal.

Figure 1 shows the block diagram of the elaborated non-linear parametric sound receiver.

![Fig. 1. The block diagram of the non-linear parametric sound receiver.](http://dx.doi.org/10.1051/jphyscol:1979818)
The non-linear parametric receiver contains the radiating high-frequency pumping piezotransducer 4, having the resonance frequency 1.25 MHz and the diameter 30 mm, and the same receiving piezoceramic transducer 5, which are placed on one axis at some distance \( L \) between them and which have a rigid coupling. The distance \( L \) constitutes the base of the non-linear parametric receiver antenna.

The high-frequency oscillator 1 oscillates high-frequency oscillations which are supplied to the radiating transformer 4 through a buffer amplifier 2 and a power amplifier 3. The oscillator has quartz frequency stabilisation, this results in reducing parasitic phase fluctuations in the oscillator itself.

The pumping transformer 4 radiates the acoustic oscillations \( V_H \) with the frequency \( W_H \) to the medium, where they interact with the received low-frequency signals \( V_C \), having the frequency \( W_C \). As a result, the piezoceramic transducer 5 receives a complex signal, which can be represented as a wave having the frequency \( W_H \) phase-modulated by means of the low-frequency signal \( V_C \) with the modulation frequency \( W_C \). The received signals are amplified 6 and detected by a phase discriminator 7, to which the standard voltage is supplied from the power amplifier 3 through the phase shifter 8. The amplifier 6 has the automatic control of transmission factor, which permits to reduce the amplitude fluctuations influence of the received signal. The signal, the value of which is proportional to the amplitude of the received signal and its frequency corresponding to the frequency \( W_C \), is singled out at the output of the phase discriminator 7. From the matching stage the signal is delivered to the amplifier 11, operating together with the input and output filters 10. Thus, \( V_{\text{output}} \) is singled out at the output of the receiver. It is the voltage \( V_{\text{output}} \) that gives the complete information about the received low-frequency signal \( V_C \).

The experimental investigation of the elaborated non-linear parametric sound receiver was carried out on a hydrosacoustic basin having the length 40 m. The base of the receiver was varied in the range 0.5 - 2 m. The source of the low-frequency signal with the range frequency of 10 - 20.000 C was located at a distance of 11 m from the receiving parametric antenna. The measurements were carried out in a pulse mode.

The experimental dynamic characteristic of the non-linear parametric sound receiver (curve 1) is presented in figure 2.

For the sake of comparison the dynamic characteristic of a hydrophone (curve 2) which represents a piezoceramic sphere having a diameter 50 mm is shown in fig. 2. The dynamic characteristics are linear in a broad range of received signals amplitudes.

Fig. 2. - Dynamic characteristics:
1 - of the parametric receiver;
2 - of the hydrophone.

Fig. 3. - Directional diagrams: \( F = 6\text{KC} \) at \( F = 10\text{KC} \), a full line - theory /2,5/.
base $L = 1$ M (the experimental values at the frequency 2KC are shown by points, at the frequency 6KC - by dotted lines, at the frequency 10KC - by means of crosses). Here the full line represents the directional diagram of the parametric receiver. According to the results of the works /2/ and /5/ the diagram was designed for the frequency of the received signal 10KC and the base of the receiver $L = 1$M.

The sensitivity of the created receiver having the ratio of the signal to the noise 30 dB was $100 \, \text{MV/Pa}$, which corresponds to the variation of the pumping wave phase $\Delta \phi = 10^{-6}$ degree/Pa and can be improved by applying some more advanced diagrams (schemes) of the phase discriminator. The sensitivity of the receiver is in a good agreement with the data presented in /5/.

The frequency range of the signals being received may be considerably enlarged both for low and high frequencies.

The experimental results of the amplitude and space directivity characteristics of the parametric sound receiver given in the report showed the possibility of practical application of the created devices in complex with the parametric acoustical radiator.

REFERENCES