Searching for objects under the sea bed by the nonlinear acoustics methods

Eugeniusz Kozaczka, Prof.
Gdansk University of Technology

Abstract

Paper presents rules of producing sources of the parametric acoustic waves as an effect of the propagation of two parallel acoustic beams. Wave is generated in the mutual impact area, with a frequency equal to the difference of the frequencies of waves radiated from the original sources. This principle is a base of the construction of parametric sonars with very narrow directional characteristics and relatively low wave frequency. Moreover, the directional characteristics do not have side lobes - a drawback of the classic sonars. Parametric sonars are a good tool of detecting objects on the sea bed and particularly those buried in the sea bed. The use of parametric sonars in searches for objects such as mines or pieces of archeological value is a modern way of carrying out directed exploration of the sea bed.

Keywords: *Sea exploration by acoustic methods – nonlinear acoustics, parametric sources*

INTRODUCTION

Exploration of the sea bottom is most often performed by means of the acoustic devices based on the generally known phenomena of the acoustic wave propagation, mainly the wave reflection and backward scattering. Classification and identification of objects on or under the sea bottom surface is extremely difficult, particularly in the latter case. The difficulties are caused by a relatively weak echo due to similar acoustic impedance properties of the wave reflecting object and its environment. Besides, damping of the elastic waves in the ground is significantly greater than in water and the wave intensity decreases rapidly. It is commonly known that wave damping, i.e. general wave energy dissipation, strongly depends on the wave frequancy. Therefore, application of the low frequency wave sources is well recommended, but it should be remembered that in general the space resolution is then reduced due to increased length of the sounding wave. This inconvenience may be considerably limited by the use of parametric sources. Parametric sonars are a kind of underwater observation and search devices of a significantly different method of operation than the classical sonars.
Fig. 1 shows the principle of sea bottom sounding with the use of parametric sonars.

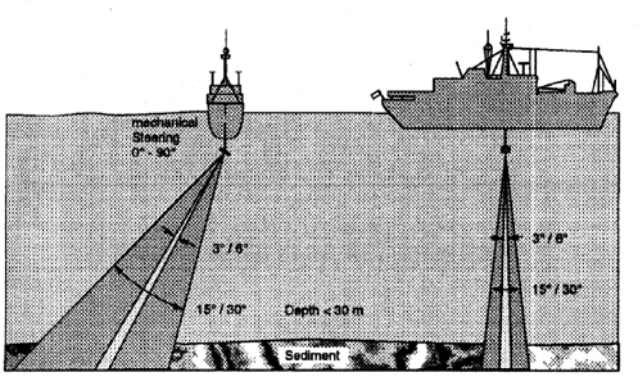

Fig. 1 *Diagram of sea bottom sounding with the use of acoustic devices*

Principle of the parametric wave generation

If two sources emit two waves of different frequencies and if those waves propagate in the same area then a nonlinear interaction takes place between the acoustic beams, which generates a wave of a frequency equal to the difference of the original wave frequencies.
The differential wave may be generated only when the original waves are of a nonlinear character.

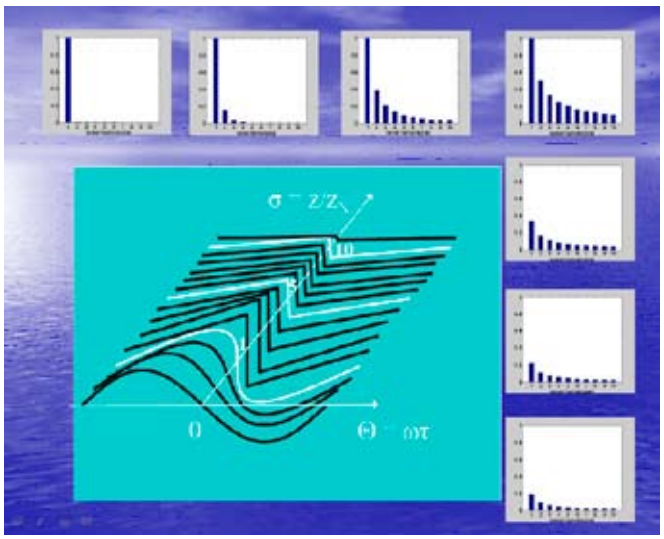

Fig. 2 *Nonlinear wave propagation principle*

An example of the use of a differential wave beam as a parametric echo sounder is shown in Fig. 3.

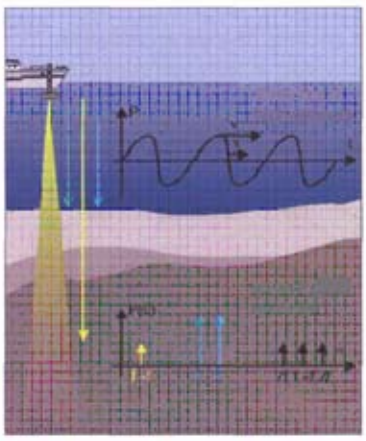

Fig. 3 *Parametric echo sounder operation principle*

An example of the use of a parametric echo sounder for the search for objects under the sea surface is shown in Fig. 4.

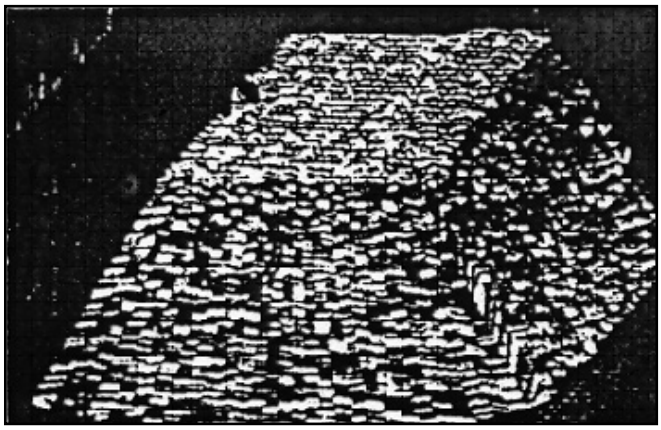

Fig. 4 *Acoustic image of an object at a 25 m depth under the sea bed surface obtained by means of a parametric echo sounder*

Fig. 5 shows a sea bed section obtained by means of a parametric sonar.

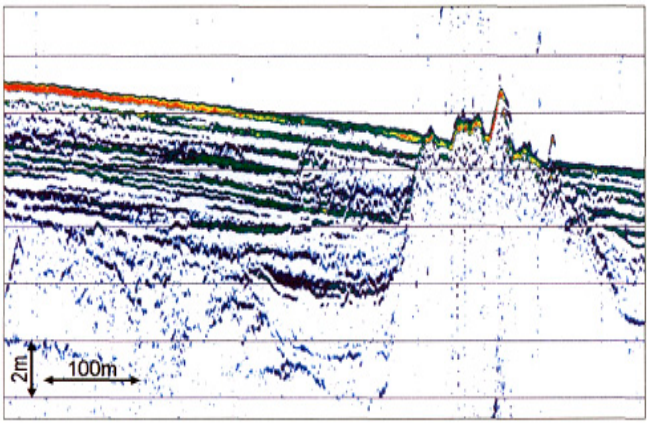

Fig. 5 *Geological section of sea bed obtained by means of a parametric sonar*

Conclusions

Parametric sonars are a modern underwater search tool. They are particularly useful in the search for small objects, e.g. sea mines on the sea bed or covered with mud. Parametric sonars are also capable of searching for objects under the sea bed, which is very important in the marine archeological investigations.

Therefore, parametric sonars extend the limits of applicability of the classical sonars. They have very good angular resolution due to very narrow directional characteristics without the side lobes.

Bibliography

1. M. Hamilton, D. Blackstock . Nonlinear Acoustics. Academic Press New York 1997
2. E. Kozaczka. Wprowadzenie do teorii akustyki nieliniowej . Akademia Marynarki Wojennej, Gdynia 1988