LABORATORY MODEL OF HIGH FREQUENCY SONAR

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This article contains the construction and laboratory application of high frequency sonar model. In view of working in laboratory conditions, they must be fulfilled succeeding parametric cases: very narrow beam, low level of side lobes and low acoustic power of transmitted impulse sounding. When all of these conditions are fulfilled, it makes possible the explanation to students some terms like depth, angular resolution and making clear, that water is the best environment to acoustic waves transmission. Furthermore, there is used automatic component, namely rotary antenna, which make possibility to precision area scanning.

INTRODUCTION

High frequency sonars are used especially to very precision search. They are characterize small range, because it is result from their physical parameters. However the small beam width (below 1deg) against low power of transmitted sounding impulse enables to observe targets in small radius from the antenna. These units are applying by a military and civilian purposes. Every kind of Remotely Operated Vehicles (ROV) are equipped of these type of sonars. Firstly the explorations are very often conducted by units, which have much lower precision. In the next step there are used high frequency sonars, up-close, almost direct contact with pinpoint target, to final observation the underwater object, which may be armed depth charge.

Sonar, which has described in the next parts, was projected and made on Gdańsk University of Technology, under the professor Roman Salamon's care scientific.

1. SONAR CONSTRUCTION

The high frequency sonar consists of three parts (hardware + software):

- The underwater section: transmit/receive antenna along with the works responsible for a head correct alignment.

The transmit/receive antenna was made of three circular piezoceramic converters. Each of them has 2.6cm diameter and they are arranged in one line. This matrix has a main frequency resonance on 524kHz. It is attached, through a sleepring, to a step motor, which is responsible for a rotation. The zero position of antenna is indicate for optical sensor. When the head passes the zero-point, there is sent a information impulse. Whole underwater section is sealed and filled with transformer oil, in order to eliminate difference of hydrostatic pressure effect and impedance adjustment of transmitted sounding impulse. This oil also characterizes very good dielectric properties, which are recommended to correctly working the electronic modules in directly location of antenna.

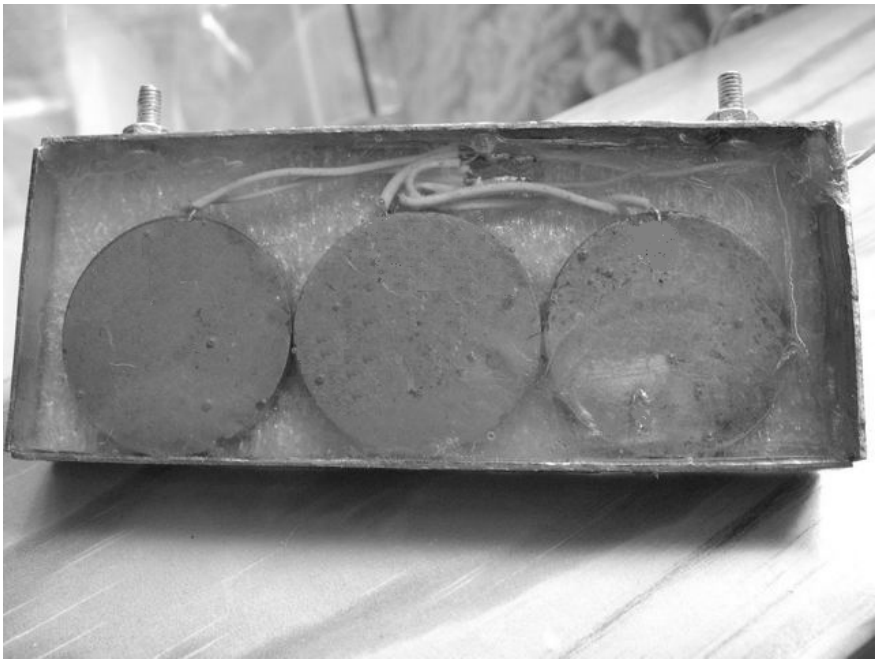

Fig.1 Transmit/receive antenna

- The overwater section: the control unit, which is responsible for a complete sonar working, communication with a personal computer and antenna.

The base control unit, called “dry” section, consists of step motor driver module, which controls rotary movement of antenna, transmit part, responsible for forming sounding impulse and finally part of processing received echo from the underwater target, which is placed in sonar’s antenna range. The transmitter generating signal in electrical form is working based on shot of loading pump. Receiver part is working with a Time Variable Gain (TVG), the Bessel band-pass filter and half-wave rectifier. The signal envelope extends time equal 70μs and is sampled with 75kHz. Next the digital data are formed in UDP frame and sent through the Ethernet controller to the local host, which is at once the control and digital data processing unit.

- Software to control and display received echo

Software, which is used to control sonar work and acquisition data visualization, is based on Graphical User Interface. Manual part is divided on two section, whereof first affects sonar controlling, second – visualization. First section makes possible to choice scan speed of around area and sector mode (antenna is scanning range on set direction and angle). Second section is responsible for changing setting of data visualization, inter alia: threshold level value, below that the data isn't take into a count, or displaying the information regarding approximate size and location target placing in a scanning range. The main part of program's window contains picture "seen" by sonar. It is displayed in 256 colors in according to received echo level.

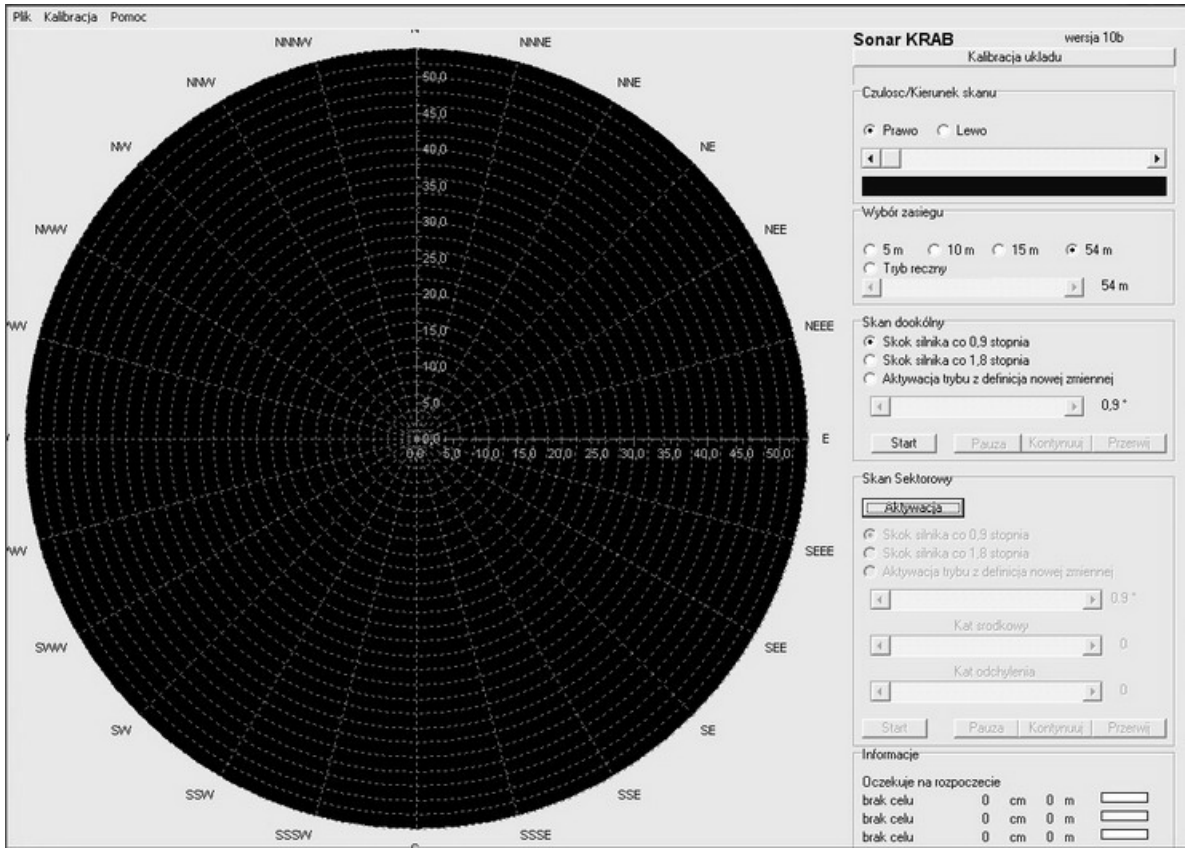

Fig.2 Control program window

2. THE PRINCIPLE OF WORKING

During the exploration with the aid of high frequency sonar, ought to entertain acoustic waves absorption effect in water environment, because for high frequencies this effect is significant. In connection with this effect, the gain range, which mostly depends on frequency, is very small.

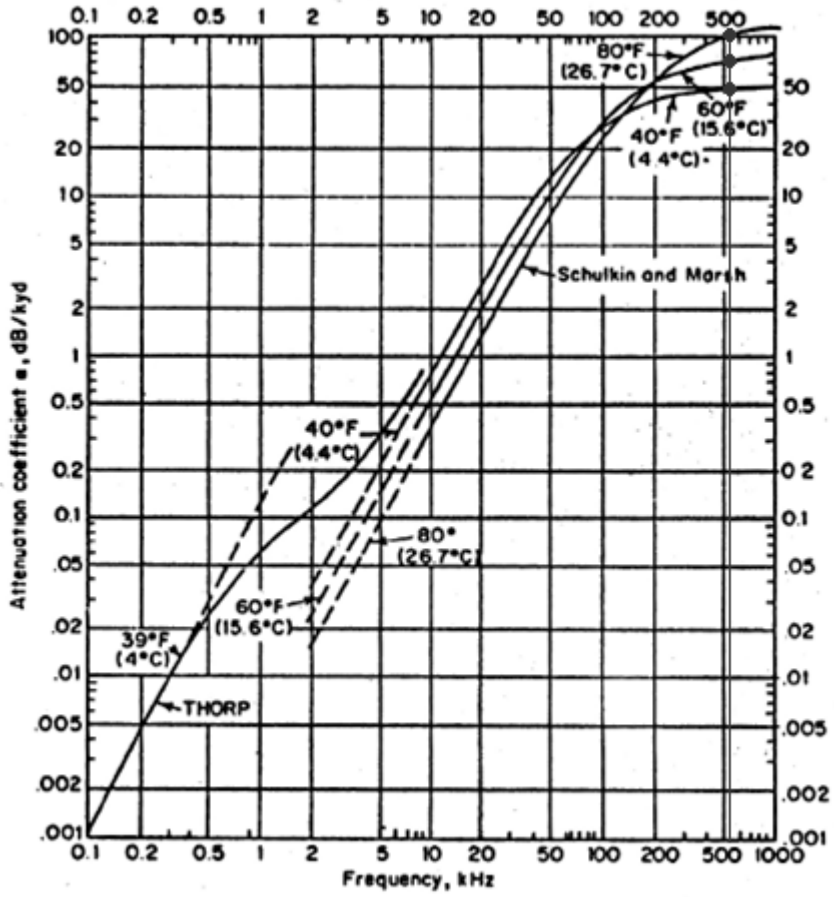

Fig.3 Attenuation coefficient in seawater as a function of frequency and temperature

The antenna was made this way to aim to cut down beam width in horizontal plane. So, thanks to beam width, there was gained adequate parameters like depth and angular resolution.

Sonar working is addicted to the software part. This program enables to turn on or off scanning mode and to change all the sets involve various sonar working modes. First step after activation sonar unit is sending information to transmitter to generate high frequency signal (524kHz), which extends time equal 70 μs. This sounding impulse has length enough to contain sufficient periods amount for this frequency. After the signal is sent, the part responsible for receiving, starts. Receiver works with Bessel second order band-pass filter and Time Variable Gain, so it makes possible to observe at once closer and further targets. After the receiver, there is a half-wave rectifier to makes envelope from signal. This form of signal enables to sample of lower frequency to change it to the digital form by the analog to digital converter. Digital signal is divided on parts, whose are formed in UDP frames. Last module of the control unit is Ethernet controller, which is some kind of network adapter. It has it's own MAC and IP address and it is identified in network like a local host. Ethernet controller is

responsible for sending packets with data in correct sequence. All of sending packets have appropriately numbers in the header parts, to make possible to recreate digital signal in correct order.

Apart from data processing section, the control unit benefits by a RS-232 controller to communication between personal computer and step motor driver.

Software installed on computer to control sonar working requires to correct operation RS-232 connection and network adapter. Panel of control unit and visualization is presented on below draws:

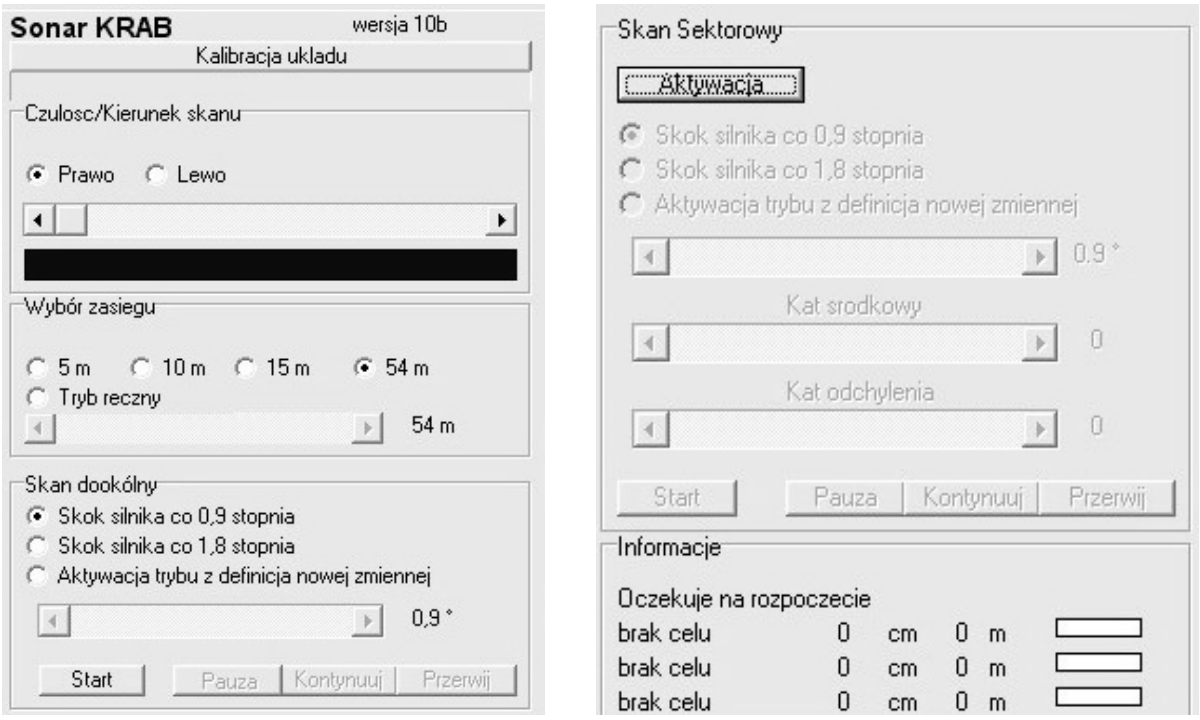

Fig.4 Sonar control and visualization section

Above, there is a part responsible for head rotating motion and menu on visualization. The button <Kalibracja układu> is used to set the antenna in zero position. In sensitivity section user may set requested threshold value, below which, values of the received data won't displayed. At the same time there is a color pointed below in line with minimal displayed echo level. In section "Wybór zasięgu" user may change displayed sonar range. Below there is a selection of motor step. There is a strict relation between motor step and underwater scanning accuracy. In the picture on right side there is sector scanning mode. In this mode user may set a direction and angle of sector. Information of target location is displayed below.

Whole program is working in a dynamic mode without requirement of return antenna to zero point. All changes are made immediately and there are visible on visualization.

3. VISUALIZATION OF RESULT IN LABORATORY POOL

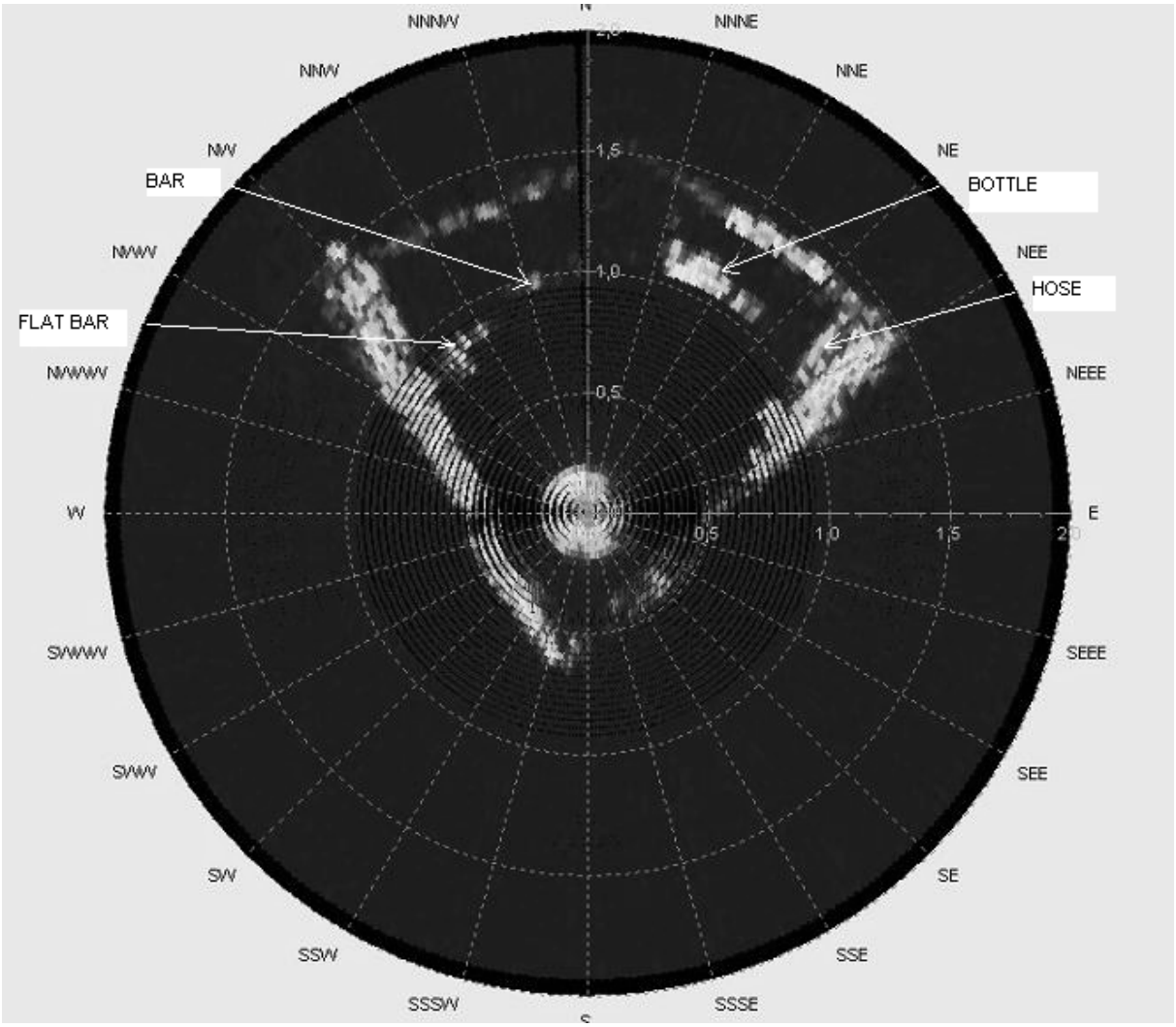

Fig.5 Laboratory poll visualization in high resolution

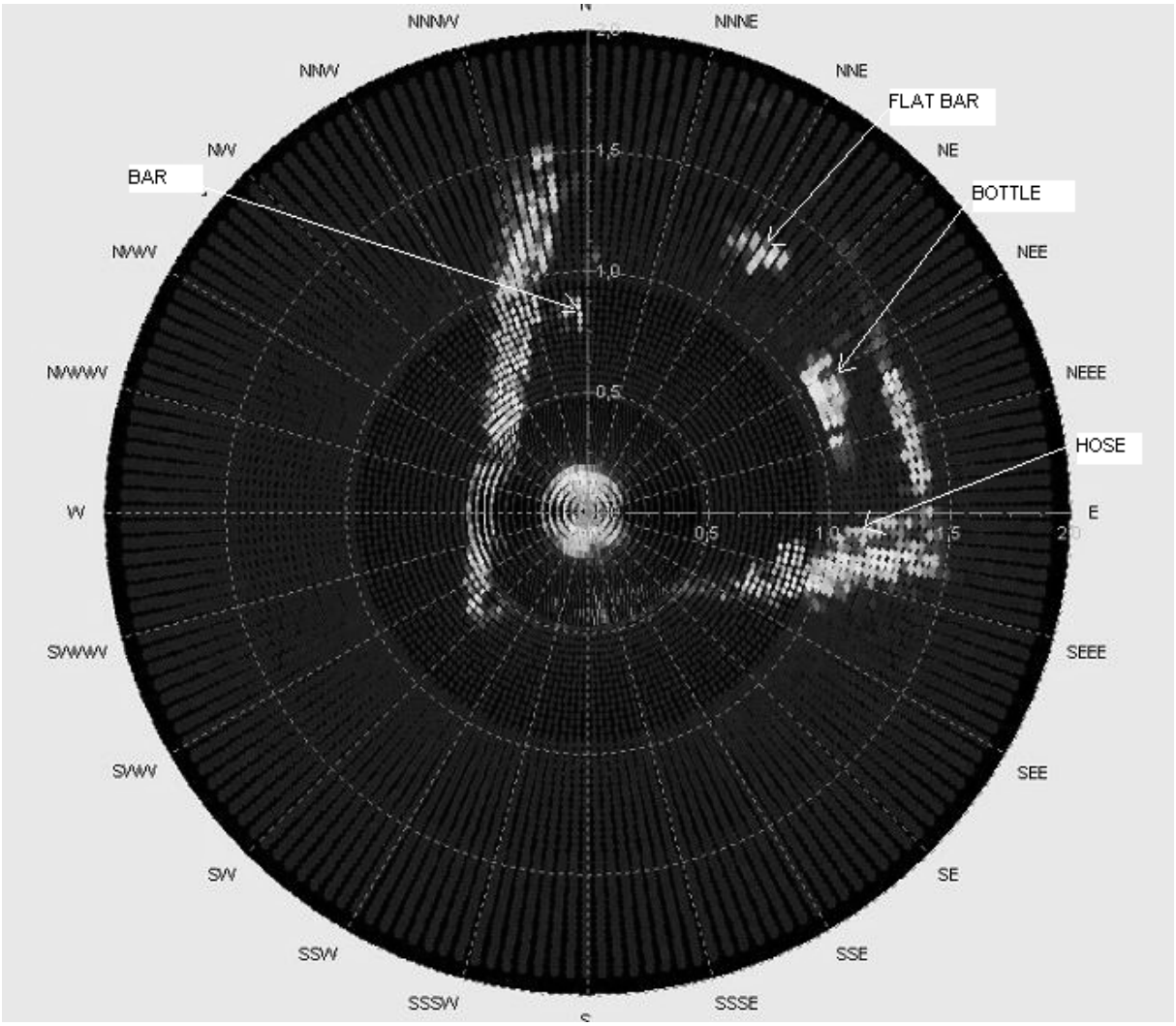

Fig.6 Laboratory poll visualization in low resolution

Above in pictures there was presented results of working sonar in laboratory pool. There was placed four different targets in water: closed bottle with air, metal bar, narrow flat bar and rubber hose filled with water. Small beam width enables to find all of them. The biggest echo was from a bottle with air, which was the biggest target level. The upper picture shows high resolution mode (Fig.5.) and in picture (Fig.6.) we can see lower resolution mode. The lower resolution is a result of bigger step of step motor, but it shortens time of whole scan (in this case two times, because of change 0.9° to 1.8°).

4. CONCLUSIONS

In our opinion implementation of this model of high frequency sonar during laboratory jobs is very good solution. It complements literature and enables to present bases of sonar working. It is the best way to convey the knowledge about construction and bases working. This sonar is accommodated to laboratory conditions. There is a addition acquired theoretical knowledge with a practical part, when students educating in hydroacoustic specialization may directly contact with a unit and may possible to testing them.

REFERENCES

1. R. Salamon, Systemy hydrolokacyjne, wyd. GTN, Gdańsk 2006.