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RECEIVING DEVICE OF INFRA LOW FREQUENCY VERTICAL ACCELERATION

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Abstract. *The short analysis of characteristics of underwater earthquakes is given. The analysis of existing technical means of measurements of their parameters for the purpose of phenomenon forecasting is provided. Need of development of the sensor the low-frequency of vertical accelerations is shown. The device constructed on the principle of modulation of nutation fluctuations of the debalanced 3-stage gyroscope with horizontally located axis of rotation of a rotor is considered. The description of a design of the device and its measuring scheme is provided.*

Keywords: sensor of low-frequency vertical accelerations, nutation fluctuations, underwater earthquakes.

Introduction

Study the Earth crust structure, measuring the parameters of the phenomena occurring in it, are very important for mankind. They are earthquakes, volcanic eruptions. These also include the human factor, for example conducting underground nuclear tests. All of this adversely affects the existence of humans and nature.

During the underwater earthquake motion of seabed soil leads to a slow ousting of large masses of water on the surface. But the waves under the point of an earthquake emergence have a height of 0,3 … 1,5 m. During the movement of the waves due to depth reduction wave height increases and on the mainland coast reaches a height of 30 … 40 m. This phenomenon is called a tsunami. It leads to the loss of human lifes and property damage. To reduce the impact of the tsunami is necessary to develop the technical means of forecasting such phenomena up to make provision and means to reduce the impact. Under the threat of a tsunami are vast territories, many heavily populated areas and even countries such as Japan, Indonesia, Thailand, and Peru. Governments of such countries that are most often exposed to tsunamis repeatedly raised the issue of creating an international system predicting the occurrence of a tsunami. Therefore, modernization, improvement of existing technical means for measuring and recording the parameters of these phenomena, as well as the development of new devices and instruments that can be used in solving the described problems are very relevant.

To solve the problem of predicting tsunamis are most likely to be used methods and technical means of geophysical prospecting.

Geophysical prospecting of minerals is one of the most progressive and modern study of Earth's bowels. Investigation of a variety of physical phenomena on the earth's surface, in mine workings, wells allows make a conclusions about the structural features of rocks, available deposits of minerals. One of the areas of geophysical exploration is seismic exploration [1].

Seismic exploration is a collection of methods of researching geological structure of the earth's crust, based on the study of elastic waves excited artificially spread. Elastic waves, which is caused by explosion or blow is spread in all directions from their source and penetrates the cortex to a greater depth. Here they like light or sound waves undergo refraction and reflection and partially returnes to the surface, where created by them vibrations are recorded by means of special equipment. Measuring the time of wave spreading, and studying the nature of the oscillations, we can determine the depth and shape of the geological boundaries, on which refraction or reflection of the wave occurred, as well as to judge about the composition of the rocks through which the wave has passed on its way.

To receive seismic signal ground seismic receivers is most widely used. Seismic receiver is a device, which perceives mechanical vibrations of soil and converts them into electrical oscillations. In ground seismic receivers inductive transducers are mainly used. Case of seismic receiver is mounted on the soil surface, and case movements exactly repeat the movement of soil. In the case of seismic receiver coil is placed, the core of which is a permanent magnet suspended in the case on a spring. During movement of seismic receiver′s case in the core current appears which have information of seismic signal′s parameters. The transfer function of the described transducer is oscillating unit. The natural frequency in modern seismic receivers is 20 ... 30 Hz. If it is necessary to record desired signals at a lower frequency, the natural frequency is reduced. The wide range of seismic receivers’ construction with induction transducers is known [1].

Statement of the problem

Estimation of the parameters of the tsunami waves is performed using analog shore recorders of level (tide gauges), which are still used in the hydrographic service. The main principles of "Hydrophysical forecast" of tsunami based on the pre-registration of tsunami waves by bottom gauges put forward in the open ocean. Modern remote sensing methods for registration (including the space) significantly expanded the capabilities of modern oceanography.

Hydrophysical tsunami forecast assumes that the sensor, mounted on the bottom provides a signal in advance. The time interval of warning should be sufficient to evacuate people from coastal areas. However, we know that the height of the tsunami in the open ocean is small and only near the coast, the wave becomes noticeable and dangerous. This means that automated recognition of the moment of the tsunami waves appearance as a record of sea level is ineffective. Problem of tsunami waves' altimetry is even more complicated. This is because the variation of level in the records due to synoptic eddies have the same spatial scale as the tsunami.

Modern operational tsunami forecast is based primarily on seismic information. Registration of strong underwater earthquake, capable of causing a tsunami is a for warning services a signal to the prompt action.

1. Defining the earthquake's source parameters(magnitude, epicenter, depth).

2. Estimation of the time of tsunami waves reaching to settlements on the coast.

3. Depending on the design time, the position of a possible tsunami source and the probability of a tsunami approach, a decision on the immediate announcement of anxiety is accepted.

The complex of equipment for marine seismic research includes selffloating standalone digital bottom stations. To implement a system of diagnosis and prediction of extreme events, it is necessary to place sensors of vertical acceleration with the help of aviation in earthquake prediction areas, composed of digital bottom stations (fig. 1).

Digital selffloating bottom seismic ADSS-1, developed by the Experimental Design Bureau in Russian Academy of Sciences, designed to study the crustal structure using artificial sources (seismic survey), as well as for detecting signals of natural seismic events on the seabed in the frequency range above 1 Hz [2].

ADSS-1 contains 3-channel seismic signals and 1-channel recording sonar signal. Station can operate in a continuous or start-stop mode registration. Using sonar communication channel we determine the distance to the station and commanded to ascend.

Fig. 1. Complex of digital ground stations

Analysis of the parameters of underwater earthquakes shows that the frequency range of crustal movements is probably 0,02 … 2 Hz. Considered receiving device is oscillating unit and at very low frequencies have a very low sensitivity. Obvious need to develop a device based on a different principle, which will measure the acceleration of very slow motions deep bottom surface.

Searching the solution

Overview of methods and technical means suitable for the task solving showed that a perspective way of receiving seismic signals of subsonic frequencies is the use of the accelerometer, built on the principle of modulation of nutation oscillations of unbalanced 2DOF gyro with a horizontal axis of the rotor rotation. Analysis of the equations describing the angular movement of the gyroscope rotor axis, shows the following. By moving the center of mass of the inner frame with the rotor due to the weight of the additional items attached to the inner frame, outer frame rotates with a constant angular velocity relatively to vertical axis. This motion is called precession. At the same time the rotor axis performs harmonic angular oscillations relatively to horizontal axis of the inner frame. This motion is called nutation. Amplitude and frequency of nutation oscillations depends on the parameters of the gyroscope (the moment of inertia and the angular rotor speed) and torque arising during displacement of the mass center.

$$M = Pl; \; P = mg,$$

where $\boldsymbol{l}$ – shift of the center of mass of the inner frame.

During moving the gyro along the vertical axis the gravity force will have the form

$$P = m\,(g \pm a),$$

where a – measured vertical acceleration. Vertical acceleration causes the modulation of nutation oscillations. Figure 2 shows an example of the reaction of an unbalanced 2DOF gyro on the vertical accelerations.

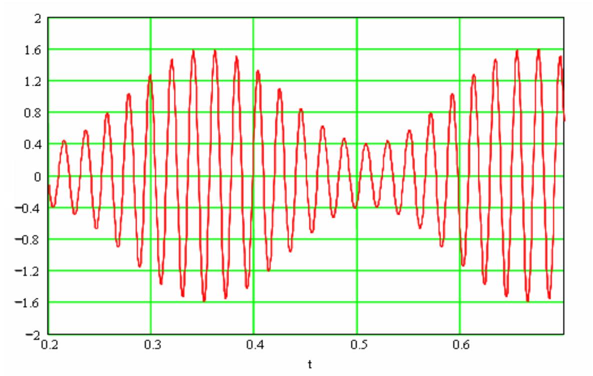

Fig. 2. Infra low frequency harmonic modulation of nutation oscillations

Mathematical modeling of nutation oscillations with specific physical parameters of directional gyro ГПК-52 showed a very small amplitude of signal. Range of linear vertical displacements end portion further details when nutation oscillations is 2–80 microns. To obtain useful information necessary to develop a primary converter micromovings.

Development of design and functional scheme of the device

Based on the above, developed sensor design infra-low vertical accelerations. Development is the modernization of direction gyro construction ГПК-52. The sensor uses a system of horizontal correction for stabilizing the position of the axis of the gyroscope rotor during rotation of the Earth. In Figure 3 is a perspective view of the structure. To the body of the inner frame 1 attached additional item 2, the outer part of which is a movable screen of differential capacitance sensor of micromoves. On the outer frame 3 housing of capacitance sensor of micromovings 4 is fixed. For balancing the outer frame of the gyroscope the balancing load 5 is mounted on opposite side.

The design of the differential capacitor converter is presented in fig. 4. Electrodes 1н, 1в are called high-potential as they join humeral windings of transformer (fig. 5) Bridge [3]. The electrode 3 is called low-potential (reception) as it joins an entrance of the amplifier of the bridge. In a gap between electrodes the mobile screen which movement changes the active areas of humeral condensers is placed. Some experiment of use of capacitor converters for measurement of micromovements is shown by possibility of measurement with an accuracy of 5 microns. It is very accepted for creation of the device of measurement of nutation fluctuations.

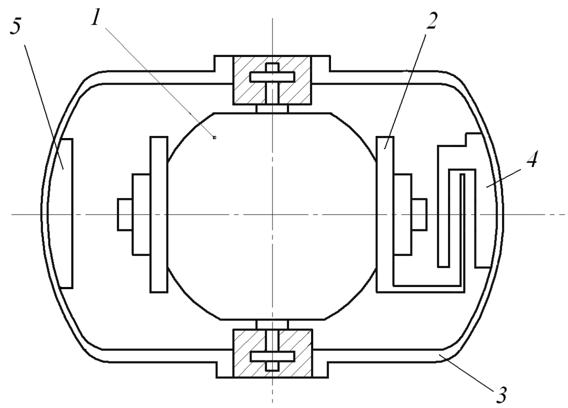

Fig. 3. Design of sensor infra-low vertical accelerations: *1* – inner frame; *2* – additional unit; *3* – outer frame; *4* – body of capacitance sensor of micromovings; *5* – balancing weight

Capacitor sensors have a number of essential advantages – the increased accuracy, temperature and temporary stability, reliability. It provides them rather wide range of application.

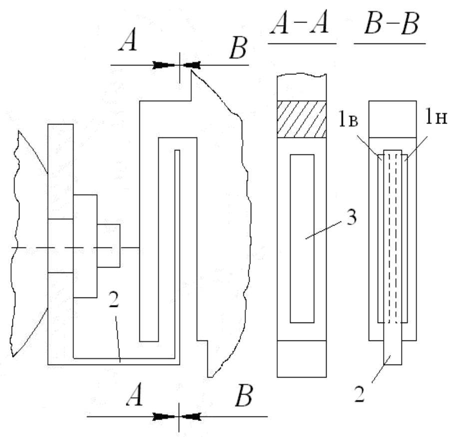

Fig. 4. Differential capacitor sensor of micromovements: 1н, 1в – the top and bottom high-potential electrodes; *2* – mobile screen of the sensor; *3* – low-potential (reception electrode)

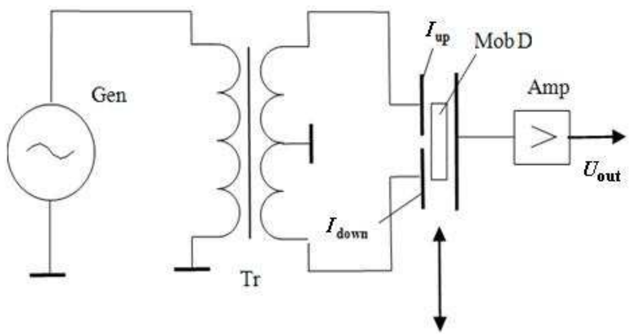

Fig. 5. Differential capacitive transducer

Conclusions

The developed device can be applied to reception the low-frequency of seismosignals. It will allow to use it in a complex of technical means of forecasting of emergence of underwater earthquakes. Results of scientific researches of structure of crust and the processes happening in Earth, also can be more exact and reliable when using the developed device reliable when using the developed device.

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А. П. Козлов, О. С. Юрченко. Пристрій прийому инфранизкочастотных вертикальних прискорень

Представлено короткий аналіз характеристик підводних землетрусів. Приведено аналіз існуючих технічних засобів вимірів їх параметрів з метою прогнозування явища. Показано необхідність розробки датчика инфранизкочастотных вертикальних прискорень. Розглянуто пристрій, побудований на принципі модуляції нутационных коливань розбалансованого триступеневого гіроскопа з горизонтально розташованою віссю обертання ротора. Приведено опис конструкції пристрою і його вимірювальної схеми.

Ключові слова: датчик низькочастотних вертикальних прискорень; нутаційні коливання; підводні землетруси.

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Напрямок наукової діяльності: ємнісні перетворювачі з неоднорідним електромагнітним полем, ємнісні прилади вімірювання геометричних параметрів маловисотного польоту повітряного судна, використання ємнісних перетворювачів у системах автоматичного керування маловисотним польотом повітряного судна.
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Напрямок наукової діяльності: дослідження і розробка методів розподілу динамічної сторінкової і сегментної пам’яті, створення систем динамічного розподілу пам’яті для операційних систем сучасних обчислювальних систем, розробка мов високого рівня для вирішення науково-технічних завдань.
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А. П. Козлов, А. С. Юрченко. Устройство приема инфранизкочастотных вертикальных ускорений
Представлен краткий анализ характеристик подводных землетрясений. Приведен анализ существующих технических средств измерений их параметров с целью прогнозирования явления. Показана необходимость разработки датчика инфранизкочастотных вертикальных ускорений. Рассмотрено устройство, построенное на принципе модуляции нутационных колебаний разбалансированного трехстепенного гироскопа с горизонтально расположенной осью вращения ротора. Приведено описание конструкции устройства и его измерительной схемы.
Ключевые слова: датчик низкочастотных вертикальных ускорений; нутационные колебания; подводные землетрясения.

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Направление научной деятельности: исследование и разработка методов распределения динамической страничной и сегментной памяти, создание систем динамического распределения памяти для операционных систем современных вычислительных систем, разработка языков высокого уровня для решения научно-технических задач.
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