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USE OF ULTRASOUND PROPERTIES IN MEDICINE

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Abstract
In the 15th century, Leonardo da Vinci tried to determine the distance between moving ships by submerging a pipe in water. Such experiments eventually led to the development of a means of detecting the sound of underwater objects (sonar) using acoustic radiation.
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Keywords: Hertz, sound, ultrasound, infrasound, vibrations, waves, acoustics, electroacoustic, membrane.

Introduction

In 1826, the physicist Colladon determined the speed of sound in water, and this method was called hydroacoustics[1].

In 1877, John William Strutt (also known as Lord Raliff) published The Theory of Sound, which became the basis of ultrasound (US).

In 1880, brothers Pierre and Jacques Curie made a decisive turn in US technology[2]. As a result of Curie's research, by applying pressure to crystals, an electric charge is created in the crystal, and they call this phenomenon "piezoelectricity". After this, different types of ultrasonic devices were developed for different purposes.

US has become an important diagnostic tool over the past 40 years. It was recognized as a leader in medical diagnostics in the 1930s and 1940s when Theodore Dussick and his brother Friedrich attempted to use ultrasound images to diagnose brain tumors. So, based on this, it is possible to say that methods of using ultrasound in medicine were proposed by scientists back in the 40s. And in 1949, American Douglas Howry invented the first medical device – ultrasound. Since there were no computers at that time, the inventors of the scanner used a camera. In the 1860s, real-time ultrasound devices were developed. Such devices gradually began to occupy almost all areas of medicine. In those years, very large and heavy ultrasound devices were also created, which were used in industry to search for defects in metal products and for other purposes.

With the development of science and technology, the following sound vibrations currently exist (Fig.):

- infrasound (IS) vibrations with a frequency of less than 16 Hz;
- vibrations with a frequency of more than 20,000 Hz;

[1] Колладон, Жан-Даниэль - Википедия https://ru.wikipedia.org› wiki› 2017.
[2] МедиАнт - Братья Кюри-молодцы!!!! https://www.facebook.com› 2022; Пъер, Кюри Википедия https:// ru.wikipedia.org› wiki› 2020.

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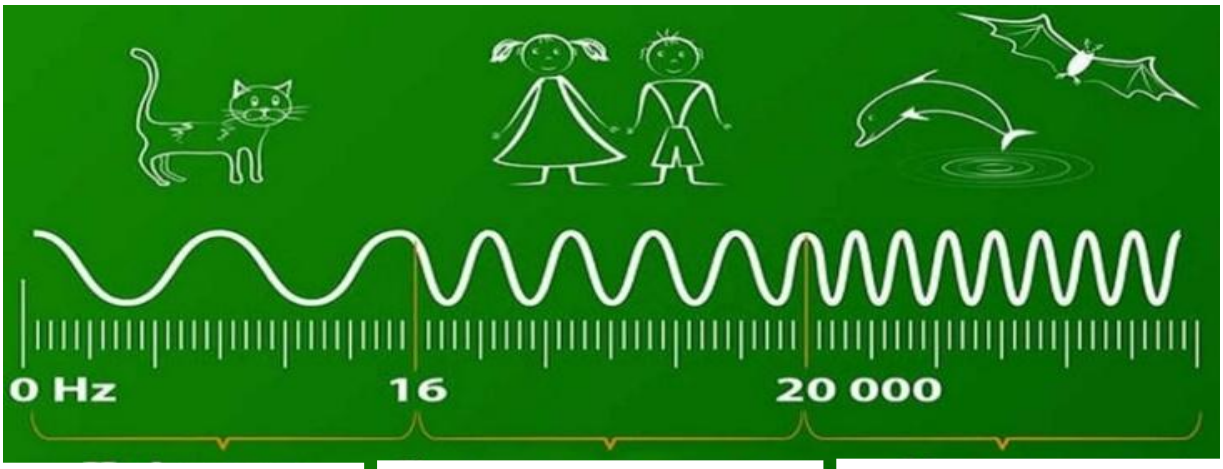
- acoustic vibrations with a frequency from 16 Hz to 20,000 Hz (Fig. 3).

US and its sources. Although the existence of ultrasound has been known for many years, its practical use began only recently. Currently, ultrasound is widely used in medicine, technology and othr fields.



IS Sound range US

Ultrasound[3] - Ultrasound is sound waves whose frequency exceeds that of the human ear, typically above 20,000 hertz US. By its physical nature, US is a mechanical or elastic wave similar to sound. The propagation speeds of sound waves and US waves are approximately the same, and the length of an ultrasonic wave is significantly shorter than the length of a sound wave. For example, the wavelength in water is 1.4 mm. Wave diffraction largely depends on the ratio of wavelengths and the size of the object from which the wave is diffracted. Therefore, some properties of US waves differ from those of sound waves.

Sources of US:

- Natural phenomena – consist of natural noises and sounds of the animal world.

Natural noises arise from natural phenomena, for example, as a component of many natural noises (the noise of wind, waterfalls, rain, sounds accompanying lightning currents);

- Animal sounds. Some animals use US waves to detect obstacles (whales, dolphins, bats, rodents, etc.). Bats, which use echolocation to navigate at night, emit signals of very high intensity. Bats reflect their signals at a pressure of only 0.001 mbar (bar-xbs, "bar" from the Greek betos - gravity) - a unit of external pressure equal to approximately one atmosphere. 1 bar, SGS can perceive a pressure equal to 105 Pa or 106 dyne/cm², which is 10,000 times less than the emitted signals. Dolphins and whales cannot see objects at a distance of more than 10-20 meters even in the most transparent water, so they rely on hearing, "feel" objects with directed US-rays, listen to sounds and echoes reflected from objects.

- Electroacoustic devices - are devices that convert electromagnetic energy into elastic wave energy and vice versa. Electromagnetic fields are widely used to measure and receive elastic

[3] Ultratovush - Vikipediya https //uz.wikipedia.org› wiki. 2019; Ультразвук - Википедия https: //ru.wikipedia.org›wiki›Ультразвук, 2022.

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vibrations in communications and sound reproduction, reception, hydroacoustics and acoustoelectronics.

- Generators with radiation - Ultrasonic radiation devices based on certain physical phenomena when generating ultrasonic oscillations in the frequency range from 18 kHz to 100 MHz and higher, for example, are all kinds of ultrasonic technological devices, ultrasonic devices and equipment for medical, industrial, and household purposes. In mechanical radiators, ultrasonic oscillations arise due to the mechanical energy of a gas or liquid flow[4].

The use of US in medicine is related to the peculiarities of its distribution and characteristic features. US, like sound, is a mechanical (elastic) wave. Electromechanical emitters are most often used to generate ultrasound in medicine. The wavelength of US is much shorter than the wavelength of sound. The greater the different acoustic impedances, the stronger the reflection and refraction of ultrasound at the boundary of dissimilar media. This occurs at the boundary between biological tissues and air. The reflection of waves in the object under study depends on the angle of incidence. The greater the angle of incidence, the greater the reflection coefficient. Therefore, the entire surface of the ultrasound device must touch the skin. The depth of penetration of US largely depends on its frequency and tissue characteristics, i.e. acoustic density[5]. For example: US with a frequency of 800-1000 kHz spreads over the body by 8-10 cm, and with a frequency of 2500-3000 Hz spreads to a depth of 1.0-3.0 cm. UT is unevenly absorbed by tissues. The higher the acoustic density, the lower the absorption. Ultrasound absorption changes during pathological processes. The compaction and rarefaction caused by US diffusion create gaps in biological fluids, which is called cavitation. Cavitation (Latin: “cavitas” – space) does not last long, but quickly closes, during which a large amount of energy is released in a small volume, the substances are heated and at the same time ionization and dissociation of molecules occurs.

During US therapy, the following physical factors affect the human body:

- dysfunction of cells and microorganisms;
- mechanical vibration of cells and tissues, microvibrations;
- breakdown of biomacromolecules;
- thermal effects, temperature of thermal tissues and increased permeability of cell membranes;
- stimulation of metabolism and regeneration processes under physical and chemical influence;
- damaging biological membranes and influencing their location, changing membrane permeability, etc.

Long-term exposure to US causes diseases of the nervous and cardiovascular systems, reduces metabolic processes in the body, negatively affects the human brain and its hearing apparatus, causes hearing loss, clogs blood vessels in the brain, increases fatigue, etc.

US-therapy is used for the following diseases:

[4] Излучатели и приемники ультразвука - studme.org. https://studme.org› 2021. Ультразвуковые преобразователи, пер. с англ., М., 1992.; Современные универсальные ультразвуковые генераторы http://utinlab.ru› universalnye-ultrazvukovye-generatory 2022.; Ультразвук - Википедия https://ru.wikipedia.org› wiki› Ультразвук. 2023.

[5] Ультразвук и его применение в медицине - Bstudy https://bstudy.net›2022; Ультразвук - FizikaBook.ru http://fizikabook.ru› 2022.

- Oncological diseases;
- Impaired motor function (paralysis);
- Hypotension, vegetative-vascular dysfunction;
- Early pregnancy (under the influence of abdominal organs);
- Thrombophlebitis, etc[6].

Types of US. Ultrasound is divided into continuous and pulsed. - Continuous ultrasound waves - this type of radiation is mainly used to affect soft tissues and joints.

- Pulsed US is a continuous radiation, i.e. US is sent regularly in separate pulses. It is softer and can be used to affect segmental zones, for example, in the elderly, in pediatric practice, with severe pain, in the acute phase of the disease, etc. is used.

US plays an incomparable role in the fields of medicine – diagnostics, treatment, surgery and laboratory analysis.

- First-line diagnostics: Exoencephalography – detection of brain tumors, tumors and blood supply; Ultrasound echocardiography measures the size of the heart in dynamics, the mass of the heart during pumping, etc.; In ophthalmology – measurement of the size of the ocular environment, determination of the amount of ocular fluid; Characteristics of heart valves using the Doppler effect of ultrasound, when assessing the volume of blood per second, when determining the speed of blood flow; In ultrasound halography when examining internal organs, determining their size, studying normal or excessive lack of fluid in the stomach and intestines, its accumulations, various tumors; the position of the fetus, its age, gender, etc.; In nephrology - the study of the function and size of the kidneys; When determining the speed of blood flow in the veins; Ultrasound speed is mainly used to calculate the density of overgrown and damaged bones, as well as to diagnose other diseases[7];
- The second line of treatment is ultrasound physiotherapy: ultrasound with a frequency of 800 kHz and an intensity of about 1 W/cm2 is used for therapeutic purposes. The main mechanism of action of ultrasound is the treatment of various inflammatory diseases using mechanical and thermal effects on tissues;
- When cutting soft and bone tissues as an ultrasound scalpel in surgery; ultrasound osteosynthesis in plastic surgery of damaged or transplanted bone tissue, etc.;
- In the laboratory, due to the destructive effect of ultrasound on microorganisms, it is widely used for sterilization of substances and for other purposes.
- In the pharmaceutical industry, various medicinal emulsions prepared with the participation of US are widely used to control the composition of drugs, in the treatment of diseases such as lung diseases, upper respiratory tract diseases, bronchial asthma, etc.

The ultrasound is a small landmark that serves as the most convenient tool for the blind, and with the help of ultrasound location, it is possible to recognize bodies and objects at a distance of up to 10 m and determine their nature.

[6] Влияние ультразвука на человека-Electrotorg https://electrotorg.ru› 2017.

[7] Ультразвук: шаг в медицину https://rostec.ru› news› 2019; Ультразвуковое исследование https://ru.wikipedia.org/wiki/2023.

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