PHYSICAL CHARACTERISTICS OF SOUND. USE OF SOUND IN MEDICINE

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Abstract *USE OF SOUND IN MEDICINE*

We receive the basic information around us through the organs of hearing and sight. In both cases, we receive information about objects without physical contact with them. Although sound and light are different physical phenomena, they are both waves. The energy carried by the waves stimulates our sensory mechanisms.

Sound is a mechanical wave emitted by a vibrating body. For example, when a tuning fork or human vocal chords vibrate, the air molecules around them move and change in response to the motion of the vibrating body. Oscillating molecules, in turn, transmit their motion to neighboring molecules. When the air vibrations reach the ear, they cause the drum to vibrate, which in turn causes nerve impulses that are received by the brain[1].

Keywords *The physical properties of sound, the acoustic spectrum, noise and its types, and the factors that cause it are discussed.*

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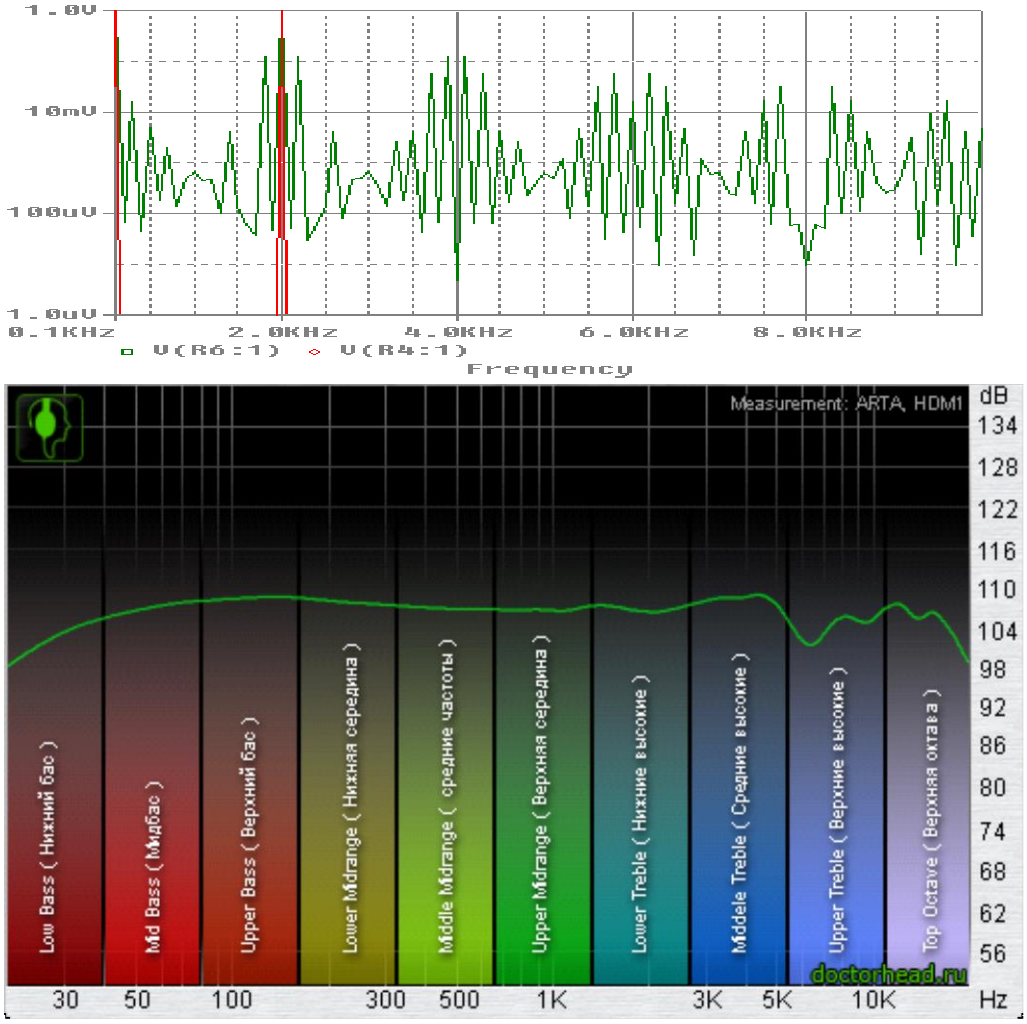
PHYSICAL CHARACTERISTICS OF SOUND.

If the frequency of the elastic waves propagating in the air is in the range of about 20 to 20,000 Hz, then they cause the sensation of sound in the human ear. Therefore, elastic waves in any medium with the specified frequency are called sound waves or direct *sound* . Elastic waves with a frequency less than 20 Hz are called *infrasound* : waves with a frequency greater than 20,000 Hz are called *ultrasound* . Infrasound and ultrasound cannot be heard by the human ear.

In gases and liquids, a sound wave can only be a longitudinal wave and consists of alternating compressions and rarefactions. Waves propagating in solids can be both longitudinal and transverse.

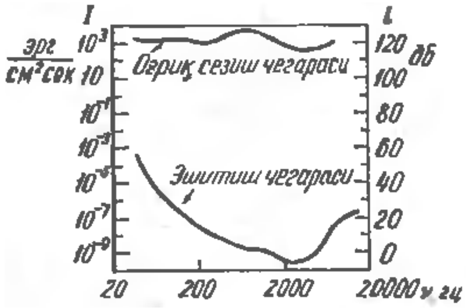
Humans perceive sounds differently in terms of pitch, timbre and loudness. Each subjective assessment corresponds to a specific physical characteristic of the sound wave.

Any real sound is not a simple harmonic vibration, but a collection of harmonic vibrations with a certain set of frequencies. The set of frequencies of vibrations involved in a given sound is called **the acoustic spectrum of the sound [2].**



. Spectral view of the amplitude-frequency relationship

The intensity of sound waves is the average value of the energy carried by the wave. A wave must have a certain minimum intensity, called the threshold of hearing, to evoke the sensation of sound. The threshold of hearing is different for everyone and depends on the frequency of the sound. The human ear is very sensitive to sounds with frequencies between 1000-4000 Hz. At this frequency, the hearing threshold is about 10^{-9} *erg/cm* ^{2} *sec* . At other frequencies, the hearing threshold is higher.



Human ear hearing and pain thresholds

the intensity is around 10^{3}-10^{4} *erg/cm* ^{2} *s* , the wave becomes imperceptible as sound and causes only pain and pressure sensation in the ear. The value of the intensity that evokes such sensation is called the threshold of pain perception.

Sound vibrations and waves are special cases of mechanical vibrations and waves. However, considering the importance of acoustic concepts in the assessment of auditory perception and its applications in medicine, it is appropriate to consider some issues. It is accepted to distinguish the following sounds from each other: 1) tones or musical sounds; 2) noises; 3) sound beats[3].

Tones and noises

Tones and Noises – These sounds can be characterized by pitch, frequency and amplitude. Here is a brief overview of each:

1. Tones: Tones are sounds that have definition, meaning they can be described as high or low. The pitch of a tone is determined by its frequency, with higher frequencies corresponding to higher pitches and lower frequencies corresponding to lower frequencies. Tones are often associated with musical notes and can be produced by musical instruments or the human voice.

2. Noises: Noises are sounds that do not have a specific pitch and are characterized by randomness and complexity. Noise can be classified into different types such as squelch (a random signal with equal intensity at all frequencies), pink noise (a signal with equal energy per octave), and brown noise (a signal whose intensity decreases with increasing frequency). . Noises can be found in everyday environments such as traffic, wind or the sound of machinery.

Both tone and noise play an important role in our auditory experience and can have different effects on our emotions, behavior and well-being.

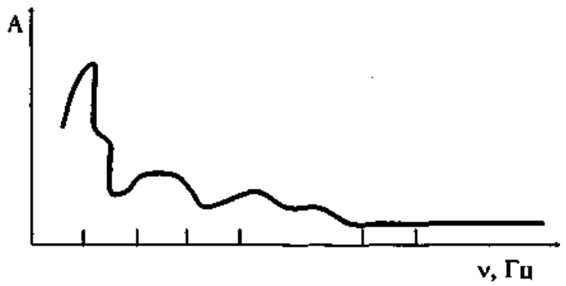
Understanding the characteristics of tones and noises helps us to evaluate and analyze the sounds around us.

A sound consisting of a periodic process is called *a tone* . If this process is harmonic, then the current is said to be simple or pure. The main physical characteristic of a pure tone is its frequency. A complex tone corresponds to anharmonic vibrations. A simple tonal sound is produced, for example, by a tuning fork, and a complex tonal sound is produced by musical instruments, light apparatus (vowel sounds), etc.

A complex tone can be divided into simple tones. The smallest frequency of the separated tones corresponds to the fundamental tone, and the remaining harmonics (overtones) have frequencies $2v_0$, $2v_0$ and so on.

A sound that does not repeat itself over time and differs in complexity is called *noise* .

Vibrations of machines, clapping, the noise of a burner flame, ghosting, rattling, consonant sounds when speaking, etc. belong to noise.



Noise spectrum

Noise can be thought of as a combination of complex tones that vary irregularly. If we try to spread the noise into a spectrum with some degree of convention, then this spectrum will be continuous, for example, the spectrum formed by noise during the burning of a gasoline gas burner.

Sound shock is a short-term effect of sound: it is produced when clapping, when there is an explosion, etc.

Shock waves and sound waves should not be confused with each other

Sound intensity. The energy characteristic of sound is measured by its intensity, like a mechanical wave. It can also be expressed in vectorial form. In practice, it is possible to evaluate the sound not by its intensity, but by the additional sound pressure generated when the sound wave passes through the liquid and gas medium. Plane wave intensity is related to sound wave pressure as follows:

$I=p^2/(2\ r\ c)$

Here r is the density of the environment; c is the speed of sound. The normal human ear perceives a fairly wide range of sound intensities: for example, at a frequency of 1 kG, $I_o = 10^{-12}$ W/m ^{2} or $P_0 = 2 \cdot 10^{-5}$ Pa (hearing threshold) to I can receive sound intensities up to $_{max} = 10$ W/m ^{2} or $P_{max} = 60$ Pa (pain threshold). The ratio of these intensities is equal to 10, so it is convenient to use logarithmic units and logarithmic scales when characterizing sound intensities. The scale of sound intensity levels is made in the following form. The value of I_0 is the initial level of the scale, and any other intensity I is expressed by the decimal logarithm of its ratio to I_0:

$L_B = lg(I/I_0)$ (5.1)

As for sound pressure

$L_B = 2lg(P/P_0)$

Expressing the above expressions in decibels corresponding to them, we write in the following form:

$L_{DB} = 10\ lg\ (I/I_0)$ and $L_{DB} = 20\ lg\ (P/P_0)$ (5.2)

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