SOUND PROTECTION BY A DIRECTED ELECTROMAGNETIC CURTAIN

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Abstract: *It is known that each noise louder than the one created by leaves in the trees can be detrimental to people's health. Nowadays, when people live mostly in urban areas, we are permanently exposed to different kinds of sound frequencies. They attack both the hearing organ, but also the nervous system which is related to the human cardiovascular system. Analyses demonstrate that the percentage of these diseases has significantly increased in the urban as compared to the peripheral areas. The available protection against sound aggression are of material nature. The most recent research conducted at the GAPE Institute in Skopje, Macedonia, indicate the existence of a new approach to protection against acoustic aggression, which is the protection by a directed electromagnetic curtain.*

ЗАЩИТА ОТ ЗВУК ЧРЕЗ ЕЛЕКТРОМАГНИТНА ЗАВЕСА

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Introduction

It is known that sound is a mechanic wave with frequencies of 16 Hz to 20 kHz, that is, within the scope perceptible by the human ear. The sound with a frequency lower than 16 Hz is called infrasound, whereas sound with the frequency of over 20 kHz is termed as ultrasound, and hypersonic are the sounds of which the frequency is beyond 1 GHz. Sound is produced more or less by periodic oscillation od a sound which, in immediate vicinity, changes the pressure in the medium (average), the pressure disturbance than being further transmitted to the neighboring medium particles, thereby appearing in the form of mainly longitudinal waves I gaseous liquids, and in the form of longitudinal and transversal waves in solids. The sound velocity mainly depends on the density and on the elastic forces in solids and liquids, and in gases on their density, temperature and pressure. Besides the usual velocity units (m/s, km/h), sound is also measured by the non-standard unit of Mach (Mach number). When an airplane reaches the sound velocity of approximately 343 m/s, the pressure in front of it is immediately disturbed, the resistance is considerably increased and shock waves are created perceived as a gunshot sound (the so-called air blast).

Sound is propagated without any mass transfer, but sound itself transfers a strong impulse and energy. In this sense, the sound intensity, the level of sound intensity (acoustics) are defined, as well as in other types of waves. But the sound propagation reveals the phenomena proper to every wave movement, as are the absorption Doppler effect, wave interference, refractions, reflection, deflection and difraction.

In music, sound is different from the tone in a narrow sense of the word and from noise regarding partial tones and partials. The tone partials are maximally harmonic, while the partial sound portions are only partially harmonic (there are more disharmonic upper partial tones than with sound), while the partial coefficients are entirely disharmonic in the case of noise. The basic features of sound (the terrain, the sound intensity, its duration and color) are the same as the basic features of the tone, but are more difficult to determine. The term “sound” is used in music, especially in its everyday experience, as well as a synonym of individual and group features of the sound (its color, for example) or of the sensed sound of some instruments or music groups (organic sound, choir sound).

Sound is propagated as a result of the elastic bond among the molecules. Sound waves in gases and liquids are exclusively longitudinal (that is, they propagate in the same direction as the oscillator particles), while they can be transversal in solids which means that the oscillator particles can also be perpendicular to the direction of sound propagation. Sound cannot be propagated in vacuum. The sound source is always some mechanical vibration of a body. For example, when hitting an object, oscillate a tensed string, we hear sound, which stops immediately after the body stops shaking. Acoustic energy is propagated in a medium in the form of a mechanical wave. This medium is usually air, but can also be a liquid or an elastic solid body. We cannot hear sound without the environment in which they would propagate (Fig. 3). According to the regularity of vibrations, we differentiate among a tone, and different levels of noise. A tone is a sound consisting of harmonious vibrations, while the different noise levels are mixtures of vibrations with different frequencies and amplitudes (Fig. 4).

Features

The sound wave moves with different speeds through different media. Its speed of movement through air is of 343 m/s, through water it is approximately 1500 m/s, and in an iron wire approximately 5000 m/s. The thicker the material, the faster sound can be transferred through it. As all other waves, sound is determined by two physical quantities: frequency and sound wave. The number of vibrations of the respective material in a second is called frequency, marked by f, and the measuring unit is one Hertz (Hz). A normal human ear is capable of perceiving sounds within the frequency range of 16 Hz to 20 000 Hz. All frequencies below 16 Hz are marked as infrastructures or sub-sounds and those over 20,000 Hz are termed ultrasounds or supersonic; they are used in engineering and in medicine. On the other hand, a wavelength is the distance between two neighboring highest densities, as well as between two neighboring dilutions of the medium through which the wave propagates. Basically, two groups of sounds can be differentiated: noises and tones. Noise is the sound created by irregular oscillation of a sound source, whereby frequency constantly changes, while a tone is produced by appropriate vibration of the sound source and its frequency is constant.

Sound sources

Sound sources are physical bodies trembling with a frequency of 16 to 20 000 Hz is an elastic medium, as is a stretched string or a tuning fork in the air. The simplest form of vibrations of a sound source is the harmonic vibration. Harmonic vibrations created harmonic waves. A clear tone is created if the trembling frequency remains unchanged. Complex tones are characterized by more frequencies. According to the Fourier’s theorem, a complex tone can be presented as a sum of sinus vibrations with a fundamental frequency of v0 and a higher harmonics of frequency $n \cdot v0$, (n = 1, 2, 3, ...). Noise is the result of entirely irregular vibrations. Waves generated by oscillation of a source with a frequency higher than 20 kHz are described as ultrasound (can be heard by some animals, as dogs and bats), and frequencies lower than 16 Hz as infrastructure (can be perceived by ducks and elephants, for example).

Sound speed

Sound speed is the speed with which a sound wave propagates in a medium. In solid mediums it depends on the elasticity, whereas in gases it depends on the isentropic (adiabatic) coefficient of the gas and its temperature and of its temperature, but does not depend on the gas density and pressure. The speed of the waves depends on the medium through which the waves propagate.

The sound speed through the air and at the temperature of 20 °C is 343 m/s (1235 km/h at 0 meters of altitude). As far as gas is concerned, the sound speed depends exclusively on the gas temperature; for example during the flight of an airplane, the higher altitude brings about a decrease of the sound speed resulting from the decrease of the air temperature at the said higher altitude.

Table 1.

Medium	Sound speed at 20 °C and at atmospheric pressure of 105 Pa
poly (vinyl chloride), flexible	80
Rubber	150
Carbon dioxide	266 m/s (на 20°C)
Oxygen	317 m/s (на 20°C)
Air	319 m/s (на –20°C)
Air	343 m/s (на 20°C)
Cork	500 m/s
Ethanol	1 170 m/s
Lead	1 250 m/s
Hydrogen	1 280 m/s
Benzene	1 320 m/s
Water	1 485 m/s
Blood	1 570 m/s
Mineral oil (SAE 20/30)	1 740 m/s
Wood, noise	3 300 m/s
Concrete	3 750 m/s
Copper	4 700 m/s
Iron	5 170 m/s
Glass	5 500 m/s
Marble	6 150 m/s
Aluminum	6 300 m/s

Sound intensity

Sound intensity (designation I) is a physical measuring describing the energy of a sound wave during a period (an interval) over a surface perpendicular to the direction of the wave propagation. The measuring unit is Watt on square meter (W/m²).

The audible threshold is the lowest sound intensity perceptible by human ear:

The sound intensity level (marked as L) is a measuring scale adapted to the sensitivity of the human ear, a tenfold logarithm of the ratio between the sound volume and sound threshold.

Decibels

A decibel (dB) is a decimal point is of the measuring unit of bell, permitted exclusively out of the SI system (International system of measuring units). A decibel is a unit at the level of a physical quantity (level of power, voltage, electricity, volume or other).

Bell

Bell (after A. G. Bell; marked as B) is a measuring unit at the level of a given physical quantity according to a selected comparative value, when that level is determined by the decadal logarithm of the ration of the values of these two quantities. A Bell is an exclusively permitted unit outside SI (International system of measuring units) related to a unit in a still unknown equation:

The unit which is mostly used is the decibel (dB = 0.1 B).

Neper

Neper (after J. Neper; Np) is a numerical unit of a certain physical quantity as per a chosen comparative value, when this level is determined by the natural logarithm of the relation among the values of these quantities; therefore its special name is number one (Np = 1). As a unit the Neper is allowed outside the SI. It is mainly used in electricity-referred communication to refer to signal suppression.

Materials and methods

Sound reflection

Sound is reflected when it encounters some obstacle. Thereby the action angle is equal to the reflection angle. In forests and in mountains, sound reflection is even more intense. The reflected sound comes back to us and we perceive it as a returning sound. This returning sound, caused by the reflection of sound waves is called echo. However, the echo can be very unpleasant indoors. In order to hear the echo separately from the original sound, we must be 17 meters or more apart from the barrier against which the sound is reflected, because otherwise the original sound and its echo merge into one single sound (Fig. 1).

Interruption and refraction of sound

The existence of dispersive sound waves is reflected by the phenomenon occurring upon explosions. Thereby, the sound waves reach the heights of the atmospheric layers at a lower temperature at which sound propagates at a lower speed. This is the reason why the sound waves refract perpendicularly to that layer. However, at the height of 40 to 60 km, the air temperature rises again, causing the increase of the sound speed, and the refraction of the waves against that vertical at a particular air layer. The range of 70 to 180 km where the sound cannot be heard is called a silence belt. The sound is again audible at the distance of 180 to 250 km.

Sound thrust is the phenomenon of sound propagation behind the obstacle as well, which is interpreted by Huygens principle. This phenomenon of sound thrust is much larger in sound than in water waves.

Sound barrier

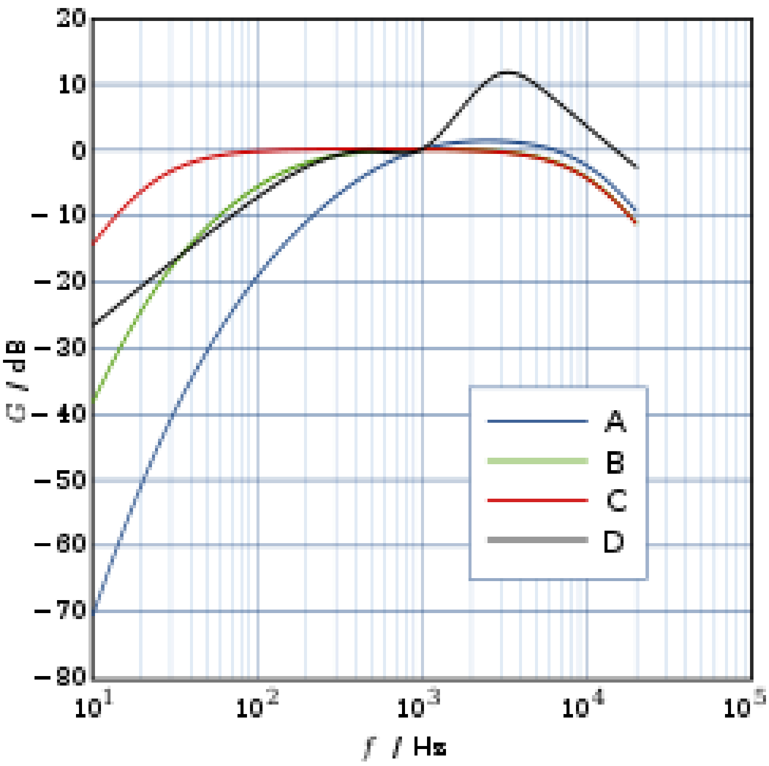
Sound barrier is an aerodynamic phenomenon incurring when the speed of sound is reached by an aircraft or by another object. Although air is considered as non-compressible liquid as low flaw speeds, it becomes compressible upon higher speed. Thus airplanes in flight disturb the pressure of the environmental air which, upon lower flow speeds is located insignificantly in front of the airplane. When the airplanes reach sound speed (depending on temperature, from 1152 to 1224 kmh), the pressure immediately in front of the aircraft is disturbed, resistance increases and shock waves are created perceived by human ear as a sonic boom. (the so-called breaking the sound wall, Fig. 2). The development of airplanes brought about speeds approximating the speeds of sound and the destructive impact of shock waves became obvious, as some airplanes were damaged when flying in that speed range. Therefore, it was believed for a long time that airplanes cannot exceed the speed of sound. But, after the Second World War, American engineers, using the results of German researchers, constructed the X-1 rocket-engine–powered aircraft, on which the pilot Chuck Yeager was the first to break the sound wall in 1947. The sound-wall was later broken by some passenger planes as for example, the French Concorde and the Russian Tupolev Tu-14y-144, which flew faster than the sound as well. For this reason, the speed of modern airplanes is expressed in a Mach number. The Mach number is the relation between the speed of the airplane and the sound speed. For example, an airplane features a Mach no. 1 if it can reach sound speed and Mach 2 if it is capable to reach a speed twice higher than the sound

Fig. 1.The echo is the return of the emitted waves reflected from a surface. The reflected wave reaches the observer with a delay in relation to the original wave.

Fig. 2. Northrop F / A-18 breaking the sound wall

Units

Table 2.



The curves A, B, C and D of the pondering factors in order
to establish the sound intensity as related to frequency
(as pursuant to EN 61672-1 / -2).

The frequency (pitch) of the sound is measured in Hertz (Hz).

The sound volume is often expressed in decibels, but can also be expressed by the power carried by sound (W, W/m², W/srad), or as an effective or maximal quantity of pressure change in relation to the pressure of the continuous medium in which sound propagates (Pa).

The decibel is a non-dimensional, logarithmic measure for the relation of two quantities and it is necessary to determine the quantity of the level of reference. As a standard, the level of sound in decibels is presented in relation to the reference of 20 μPa, which, in general, complies with sound threshold, usually marked by adding the SPL (Sound pressure level). For example, a whisper has 30 dB (A) SPL, speech has 60 dB (A) SPL, noise 90 dB (A) SPL, and the sound with the intensity of 120 dBSPL has been termed as pain limit. When expressing it, the fact that the human ear is not equally sensitive to all frequencies is taken into consideration. Therefore, pondering factors have been defined in order to determine the meaning in which a certain frequency is taken into consideration upon the measurement of sound intensity. For the human ear, these pondering factors are given as a curve A (according to EN 61672-1 / -2), and the measurements based on these pondering factors are called dB (A), sometimes known as dBA or dBA.

A decibel is a measure derived from the unit of Bell (B) named in honor of A.G. Bell, inventor of the telephone. But, for practical reasons, it uses a ten times higher logarithmic unit of decibel (dB). The auditory sense of volume is based on a physiological effect, that is, on the stimulation of the auditory nerves. Therefore, it is necessary to conclude that this auditory sensation depends on the sound intensity, that is on the sound pressure. Testing revealed that each clear tone demanded a minimal acoustic pressure to be heard by human ear. That minimal pressure under which a tone is audible is the threshold or sound limit. However, sound pressure can again be so high to cause ear pain, for which it is termed as pain limit. The sense and limits of pain depend on frequency, meaning that they differ in different frequencies. The sensitivity of our ears is the highest for frequencies of approximately 2700 Hz. The human ear experiences sound as a caused change in the air pressure (acoustic pressure). For a sound wave with the frequency of 1 kHz and intensity corresponding to the sound threshold (I0 = 10–12 W/m²), the particle movement amplitude is approximately 10–11 m, while the amplitude of the acoustic pressure is approximately 2 · 10–5 Pa. In the pain threshold sound, the particle movement is of 10–5 m, and the acoustic pressure amounts 30 Pa (Table 3).

Table 3

Sound type	**Sound intensity (fon)**	
Sensation threshold	0	
whisper	20	
Quiet music	40	
Loud speech	60	
A busy street	80	
An express train passing	100	
Airplane engine	120	
Pain threshold	130	

Fig. 3. Propagation of sound waves

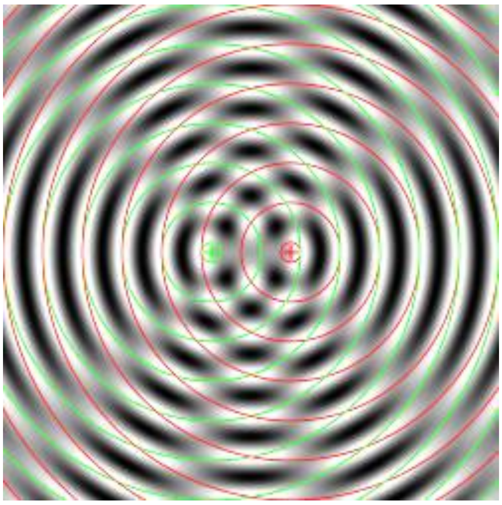


Fig. 4. Noise from two sources of acoustic waves

Results

New and innovative technologies are necessary for the protection of the environment against excessive sound (noise). One of them is this technology, created by Stojan Velkoski, Ph D from Skopje, Macedonia. This innovative technical invention is in the course of testing and manufacturing at the IGAPE Institute in Skopje. This patent shall be capable to isolate sound so that strong sound influences exist in one half of a room, whereas the sound is not enhanced in the other half of the same room thanks to sound curtain created by the two elements. The sound curtain consists of two directional waves that intersect to constitute the 50–100 cm wide sound curtain The invention consists of the following elements:

- frequency emitter;
- frequency router;

Description of the attached figures

Fig. 5, represents a frequency emitter, A potentiometers, Б display;
Fig. 6, represents: A, router and B, router base;
Fig. 7, this picture present the connection and the setup of the elements of the Waveguard sound protection.

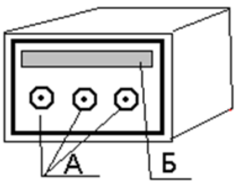


Fig. 5. Frequency emitter

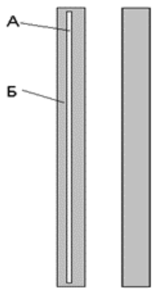


Fig. 6. Router and buffer of frequencies

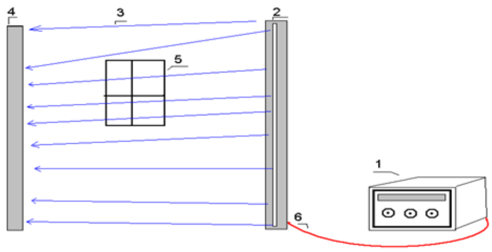


Fig. 7. Setup and creation of electromagnetic directional curtain

Summary

All the above leads to the following conclusions: that the matter is an obstacle to matter, while in case of electromagnetic radiations matter is not always an obstacle and vice versa, matter does not do not represent any obstacle to electromagnetic waves. Hence the new thesis, that the electromagnetic waves can be impeded by another type of electromagnetic directed waves including sound waves.

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