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PROTECTION INCREASE OF SPEECH INFORMATION BY USING GLASS PIPES ON WINDOW FENCES

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The paper proposes and justifies a way to increase the security of speech information by attaching glass tubes (stiffeners) to a window fence. A method for estimating changes in the resonances of a window enclosure with fixed stiffeners is given. With the help of the developed laboratory installation, a study of the window fence was performed. Calculated indicators of changes in the maximum resonance of window fencing with stiffening ribs installed.

Introduction. Isolation of the airborne noise of a room is its most important characteristic in terms of protection against leakage of voice information. Of all the elements of enclosing structures, window barriers are most vulnerable to attenuation of sound frequencies. In [1], an assessment of the sound insulation of airborne noise by window barriers by changing the calculation of the thickness of the glasses and increasing the air gap between them is given, the use of glasses with different thickness and the intervals between them is justified for the greatest security of speech information. However, in practice, changing the thickness of the glass and the distances between them is not always possible.

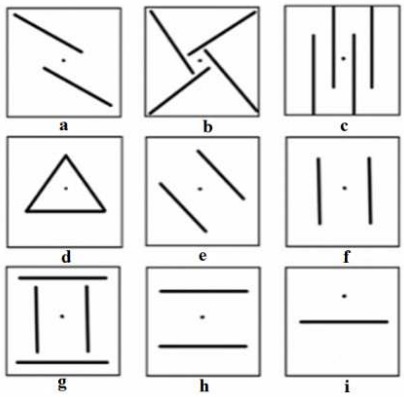
To reduce the sound level, the use of sound insulation is more effective than the use of sound absorption indoors [2]. So in the study of metal structures, for example, in [3], in order to increase the rigidity of window barriers, it is recommended to change the geometric parameters of the window barriers - the shape of the section. When designing metal structures, the main practical means of increasing rigidity is to maneuver the geometrical parameters of the system, and not the characteristic of metals, which is determined only by the completely atomic-crystalline lattice of the main component.

The easiest way to reduce the strain of metal structures is to reduce the level of stress (increase the structure). However, this path is not always rational, since it is associated with a significant increase in the mass of the structure. In the case of bending, a rational way to reduce deformations is to choose the most optimal form of sections, loading conditions, type and arrangement of supports.

By analogy with metal structures, this paper proposes the installation of stiffeners on a window fence, which changes the cross-sectional shape of a window fence and is a more rational alternative to changing the thickness of the glasses and the distances between them.

Stiffening ribs window fencing. Stiffeners can be used without replacing window fencing. Stiffeners are transparent glass tubes made of quartz sand and some other materials that do not disturb the interior and exterior. Fastening of the ribs is ensured by a snug fit to the glass of the window enclosure and the application of adhesive along the position of the rib to the window enclosure.

Placing the glass tubes on the window fence can be done in various ways (schemes of ribs). The stiffener scheme is a method of arranging glass tubes on the glass of a window enclosure. Some possible stiffener patterns that were studied on are shown in Figure 1.



a - parallel shifted; *b* - mill; *c* - four shifted; *d* - triangle; *e* - two parallel oblique; *f* - parallel vertical; *g* - two vertical and two horizontal; *h* - parallel horizontal; *i* - single
Figure 1. – Schemes of ribs

Window fencing is schematically depicted by a square, inside of which one of the schemes of stiffening ribs is shown by straight lines, the vibrator is depicted by a dot in the center of the square.

Depending on the stiffener scheme used, the maximum resonance of the window fence varies. Estimation of the change in the maximum resonance is proposed to be performed in a laboratory setting using the technique presented below.

Technique for the study of resonances. The level of protection of speech information in [1,4,5] is usually described using the information indicator - speech intelligibility. To assess intelligibility, the frequency speech range (100–10000 Hz) is divided into equal-articulation bands, which make the same contribution to speech intelligibility [4].

The maximum resonance of a window fence is the most powerful resonance in a band of equal speech intelligibility, the smaller the value of the maximum resonance, the more protected is the speech information in the band. The main indicator in the method is the total change in the maximum resonance of a window fence with installed stiffeners to the window fence without installed stiffeners, expressed in decibels.

The application of the resonance research technique and experiment is impossible without creating a laboratory setup. A laboratory setup was created, on the basis of which a study of resonances was conducted.

Results. The experiment was carried out in a laboratory at an ambient temperature of + 18 °C. The measurements were carried out in the frequency range from 100 to 10,000 Hz. The calculated value of the total resonance change for a window enclosure without fixed stiffeners was 0.1117 V.

Table 1 presents the obtained indicators of changes in the level of maximum resonances of a window fence with fixed stiffeners to the window fence without installed stiffeners.

Table. – Indicators of changes in the maximum resonances of the window fencing with fixed stiffeners to the window fencing without installed stiffeners

Indicatorschangesresonances	Stiffener Schemes								
	a	b	c	d	e	f	g	h	i
Sum max. resonance amplitudes $\sum_{Ri}$, V	0.1215	0.1016	0.099	0.1005	0.0993	0.1135	0.0979	0.1003	0.1038
Levelchanges max.amplitudesresonances with installedribsstiffness δ_n, dB	0,7304	-0,8231	-1,0483	-0,9177	-1,0220	0,1388	-1,1454	-0,9350	-0,6371

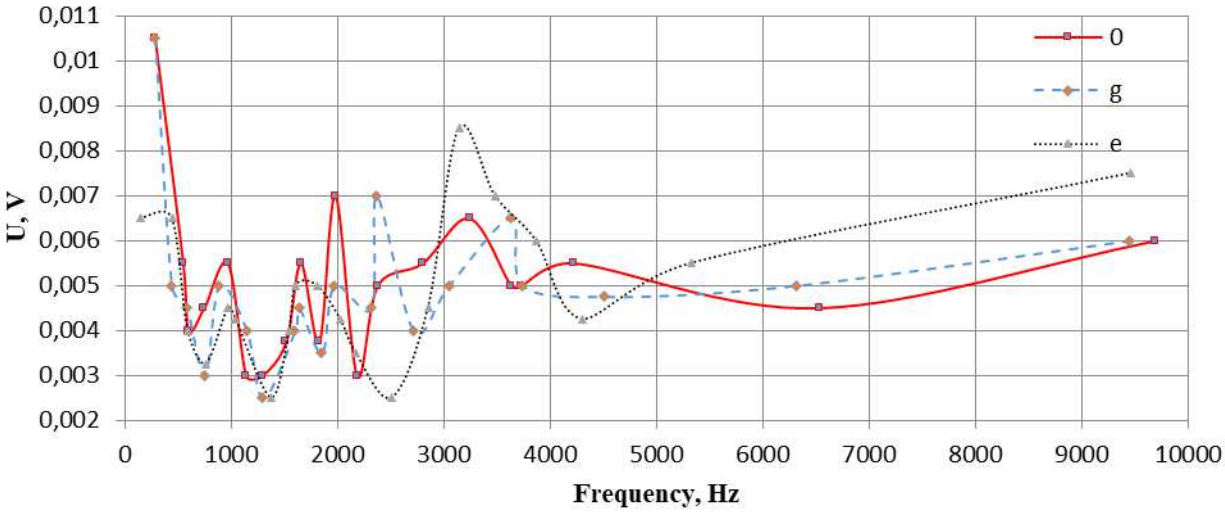
From Table it can be seen that the scheme g has the maximum level of variation of the maximum amplitudes of resonances, and the schemes a and f, on the contrary, increase the intensity of the sound wave due to the resulting resonances. Scheme g showed an increase in the security of speech information by 12.3%, compared to window barriers without stiffeners.

For example, figure 2 shows the frequency response of the circuits with the highest rate of change in the level of the maximum amplitudes of resonances using 4 and 2 stiffeners e, g and window fencing without stiffeners installed on it.

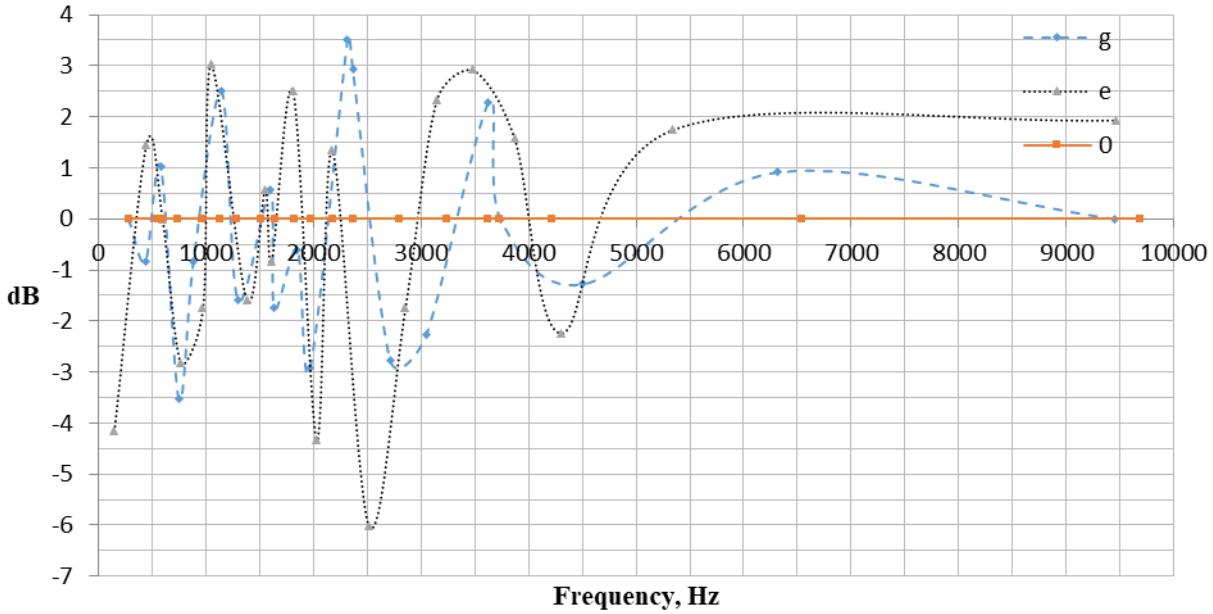
The graph shows that for circuits g and e, the resonance is shifted in frequency. So when using the g scheme, the resonance from the frequency of 3240 Hz of window fencing without installed stiffeners shifted to the frequency of 3048 Hz, the level of voice information security increased. A scheme e in this frequency band shows a decrease in the level of security of speech information and the shift of the resonance from 3240 Hz to 3146 Hz. In general, in all bands, g and e circuits showed an increase in the level of voice information security.

To increase the visibility of the frequency offset of the resonances, Figure 3 shows the dependence of the change in the maximum resonance level on the frequency when stiffening ribs are installed, with respect to the resonances of the window fencing without stiffening ribs, calculated by fomule:

$$i = 20\lg\frac{U_{Ri}}{U_{R0}}, \partial Б .$$



0 – window fencing without stiffeners; *g* – two vertical and two horizontal; *e* – two parallel oblique
Figure 2. – Schemes e, g and window fencing without stiffeners installed on it



0 - window fencing without stiffeners; *g* - two vertical and two horizontal; *e* - two parallel oblique
Figure 3. – The dependence of the change in the maximum level of resonance on the frequency when stiffening ribs are installed

In Figure 3, the graph shows how much the maximum resonance level with the stiffening ribs has changed. The positive values of the graphs on the ordinate axis reflect an increase in the maximum resonance - a decrease in security. Negative values - decrease in the maximum resonance or increase the security of speech information. Ideally, the stiffening ribs should be plotted in negative values of the y-axis for all frequencies. The absence of a change in the maximum resonances plots the graph along the ordinate axis. For the presented values, the graphs clearly show the change in the frequencies of maximum resonances with stiffening ribs installed. The change of resonances for most bands in the range from -6 to 3.5 dB is also traced.

Conclusion. The paper proposes and justifies a way to increase the security of speech information by attaching glass tubes (stiffeners) to a window fence. Fastening stiffeners allowed in various schemes. Some of the possible schemes investigated in the work showed a decrease in the overall maximum resonance of window barriers, which increases the security of speech information.

With the help of the developed laboratory installation, a study of the window fence was performed. Calculated changes in total maximum resonance when stiffening ribs are installed.

As a result, it was revealed that:

1. The scheme of stiffeners **g** (two vertical and two horizontal glass tubes) has the highest level of attenuation of the total maximum resonance, and shows an increase in the level of protection of speech information by 12.3% or -1.145 dB compared to window fencing without stiffeners.

2. When using stiffeners, in addition to changing the level of the maximum resonance, there is the effect of shifting sound resonances. The offset of the sound frequencies of the resonances depends on the stiffening ribs scheme used. Thus, by selecting the most optimal stiffener schemes for window fencing, it is possible to eliminate or reduce the resonances of the window fencing.

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