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(54) A DAMPING AND SOUND-ABSORBING PLATE MADE OF FIBER MATERIAL AND AN ACOUSTIC SILENCER MADE OF THIS PLATE

(57) Silencing and sound-absorbing panel made of fibrous material, preferably mineral wool, characterized in that it has many recesses (3, 6, 7, 8, 9, 10, 12), the depth of which (H) is 30-60% of its thickness (G1) and on at least one surface it includes a cladding (2) made of glass veil or glass fabric or canvas or polyester non-woven fabric or a vapor-permeable or vapor-tight membrane. Acoustic silencer comprising acoustic baffles, characterized in that the acoustic baffles are filled with a panel, the panel made of fibrous material, preferably mineral wool, has many recesses (3, 6, 7, 8, 9, 10, 12), the depth of which (H) is 30-60% of its thickness (G1).

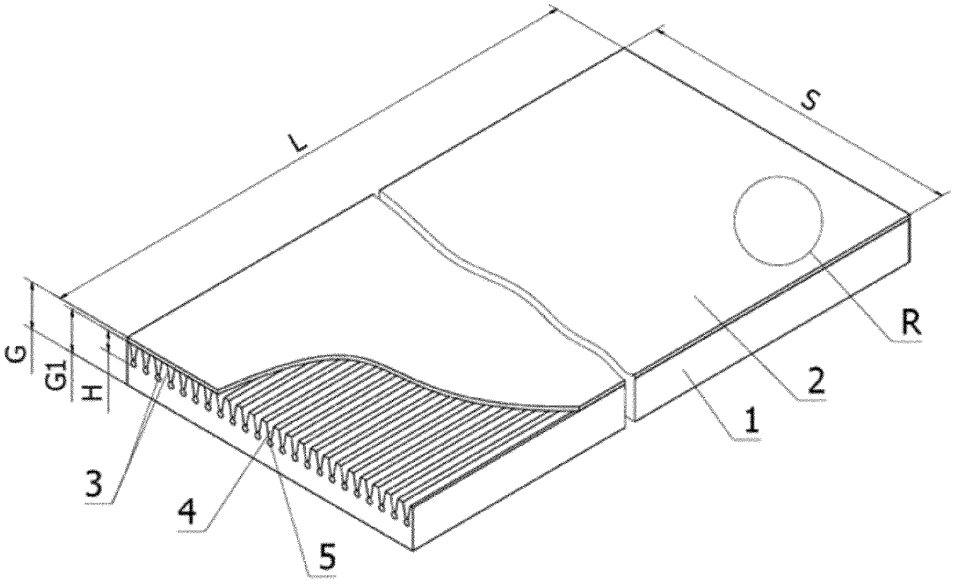

Fig. 1

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Description

[0001] The subject of the invention is an insulating and sound absorbing panel made of fibrous material, especially made of mineral wool, intended for thermal and acoustic insulation of ducts ventilation, plenum boxes, filling gap acoustic silencers, screens, screen absorption silencers, sound absorbing panels and as internal sound insulation in industrial and ventilation devices. The subject of the invention is also an acoustic silencer made from this panel.

[0002] A well-known and commonly used method of noise (sound) suppression in installations ventilation, industrial equipment or road architecture consists in using absorption silencers, usually made in the form of screens or sound-absorbing panels, in which the basic function is performed by the noise-absorbing material in the form of mineral wool, having an appropriate sound absorption coefficient in a given band of the acoustic spectrum. In addition, an important function of the sound absorption capacity of such a silencer is played by its overall dimensions and the design solutions used in it, because with the increase in its dimensions, its attenuation coefficient also increases. However, the basic disadvantage of these silencers is that under certain temperature and humidity conditions of their use, they create favorable conditions for development of microorganisms (fungi and bacteria) that may be a source of emissions air pollution, especially in ventilation systems.

[0003] Mineral wool panels under the trade name "ParocInVent" are known also for acoustic and thermal insulation of ventilation ducts with a mineral wool core with a thickness ranging from 30 mm to 150 mm and a density of 40 kg/m^3 to 120 kg/m^3, which is covered on one or both sides with a veil facing glass or fiber using a two-component polyurethane adhesive.

[0004] Mineral wool panels are known under the name Rockwool INDUSTRIAL BATTS BLACK also intended for acoustic and thermal insulation of ventilation ducts and for construction of acoustic silencers, slot and chamber silencers and sound-absorbing screens.

[0005] The state of the art also includes sawdust concrete slabs for soundproofing purposes containing grooved circular resonance recesses on one surface, and on the other surface trapezoidal ribs. The main disadvantage of these panels is their high weight (density approx. 1000 kg/m3), more than 10 times higher than mineral wool panels, which makes it difficult to use in slot silencers. Moreover, the sound absorption coefficient for sawdust concrete slabs in high frequencies is significantly lower (worse) than in in the case of fibrous materials, in particular mineral wool.

[0006] US document US1628090A discloses a plate or slab for a specific purpose such as sound or vibration damping comprising a sheet of flexible material and elastic elements connected to said sheet arranged horizontally and each forming with an acute angle with the plane of said plate or slab on one side and an angle on the opposite side obtuse with said plane. In Fig. 8 the inclined projections have been replaced by ribs.

[0007] In turn, the insulating mat known from the Polish description of utility model No. PL64249, used as thermal and acoustic insulation of buildings, it consists of polyurethane foam with a closed-pore cell structure, bonded to a layer on one side metallized foil.

[0008] It is also known from the Polish description of utility model No. PL60681 mat insulation for acoustic and thermal insulation of rooms and roofs, which constitutes a rectangular strip of the mat in the form of a solid polyethylene shell combined in one piece with mat made of foamed polyethylene, in the cross-sectional plane of the layer these are offset from each other over the entire length of the mat along one side to form a lateral shoulder of this coating on which the adhesive element is placed, enabling it its precise installation, obtaining full vapor barrier and avoiding the formation of acoustic bridges.

[0009] The aim of the invention is to develop a simple, compact, and cheap panel structure of the increased effectiveness of sound (noise) attenuation. The object of the invention is to improve attenuation panels of known materials in different frequency ranges, which would allow to obtain dumper matched to a specific noise source.

[0010] The object of the invention is also the construction of the panel facilitating the construction of active noise silencers.

[0011] Another object of the invention is also to limit the development of microorganisms in the panels thus reducing the emission of air pollutants.

[0012] According to the invention, a damping and sound absorbing panel made of fiber material preferably made of mineral wool, has many recesses, the depth of which is 30-60% of its thickness and on at least one surface it includes a cladding made of glass veil or glass fabric or canvas or polyester non-woven fabric or a vapor-permeable or vapor-tight membrane.

[0013] Preferably, the recesses are on one side of the panel.

[0014] Preferably, the recesses are trapezoidal grooves arranged vertically and symmetrically to each other, the lower ends of which are connected with circular cutouts located horizontally along the panel.

[0015] Preferably, the profile recesses in the vertical section have the shape of the letter "U" and are located along this panel and symmetrically and parallel to each other.

[0016] Preferably, the profile recesses in the vertical section have the shape of the letter "V" and are located along this panel and symmetrically and parallel to each other.

[0017] Preferably, the panel has a plurality of vertical cylindrical recesses.

[0018] Preferably, the panel has pairs of recesses located alternately and symmetrically and parallel to each other, with pairs of recesses in the vertical section having U-shaped profiles, and pairs of recesses having equilateral trapezoidal profiles, and between these recesses there are vertical recesses in the shape of cylinders of the same depth, what U-shaped and trapezoidal recesses.

[0019] The essence of the invention is also an acoustic silencer containing acoustic baffles filled with a panel of fibrous material, preferably mineral wool, which has many recesses, the depth of which is 30-60% of its thickness.

[0020] Preferably, the recesses in the silencer extend transversely to the inlet of the silencer.

[0021] Panels with profiled grooves and/or cylindrical recesses significantly increase the active noise attenuation surface, which in turn results in an increase in the attenuation efficiency.

[0022] Numerical studies performed using the FEM method show the possibility of adjusting the noise suppression (tuning) capabilities of the silencer using the panels according to the invention in the 500 and 2000 Hz octave bands.

[0023] The recesses of various shapes in the sound-absorbing panels allow you to adjust the characteristics of the silencer to the sound source.

[0024] The membrane, fabric or glass veil applied on the surface provide a flat surface of the panel, reducing the resistance to air flow through the silencer. Keeping the hob surface clean is also easier. The veil also prevents particles of wool or other panel material from being entrained by the airflow.

[0025] The panel according to the invention can also be a base for applying bactericidal, fungicidal and virucidal preparations in its cavities, as well as devices for their application. This can prevent the development of microorganisms in all climatic and temperature conditions, which are the source of air pollutant emissions, regardless of the purposes for which they were used.

[0026] In the recesses, one can also place heating cables or sound emitters for construction active noise suppressors.

[0027] The subject of the invention has been described in more detail and shown in the examples of its implementation on a drawing in which:

Fig. 1 shows the first version of the insulation and sound-absorbing panel with longitudinal trapezoidal-circular grooves after partial removal of the cladding from it, in a perspective view,
Fig. 2 - enlarged detail "R" of this panel in vertical section,
Fig. 3 - the second version of the insulation and sound-absorbing panel with longitudinal rectangular grooves, after partial removal of the cladding from it, in a perspective view,
Fig. 4 - the third version of the insulation and sound-absorbing panel with longitudinal V-shaped grooves, after partial removal of the cladding, in a perspective view,
Fig. 5 - the fourth version of the insulating and sound-absorbing panel with cylindrical recesses, located symmetrically and parallel to each other, after partial removal of the cladding in a perspective view,
Fig. 6 - an enlarged detail of the "T" of this panel in a vertical section,
Fig.7- the fifth version of the sound-absorbing insulation panel with pairs of longitudinal rectangular and triangular grooves located alternately and parallel to each other, and with cylindrical recesses made on the other surfaces of the core separating these pairs of grooves, after partial removal of the cladding, in a perspective view,
Fig.8 - enlarged "Z" detail of this slab in vertical section,
Fig. 9 shows a simplified acoustic silencer with panels containing recesses in the shape of rectangular grooves on both sides
Fig. 10 shows the attenuation characteristics of various variants of the shapes of the recesses

Embodiment 1

[0028] The insulating and sound-absorbing panel shown in Fig. 1 and 2 has the shape of a flattened cuboid with a length of L=2000 mm, a width of S=1000 mm and a thickness of G=100 mm, and its core 1 is a well-known PET fiber wool (PET eco-wool), for one surface of which is permanently attached with a solvent dispersion adhesive cladding 2 made of glass veil, while under this cladding, on the surface of this core, profile recesses 3 are made, which are vertically located trapezoidal grooves 4, connected at their lower ends with round cutouts 5 located symmetrically along this panel and parallel to each other, and their total depth H is 50% of the thickness G1 of core 1.

Embodiment 2

[0029] The insulating and sound-absorbing panel shown in Fig. 3 has the shape of a flattened cuboid with a length of L=2000mm, a width of S=1200mm and a thickness of G=60mm, and its core 1 is a well-known mineral wool with a density of approx. 80 kg/m3, to which on one surface, a cladding 2 made of glass cloth is permanently attached, while under this cladding, profile grooves 6 are made on the surface of this core, having a rectangular shape in the vertical

cross-section and in the view from its front. For ease of reference hereinafter in the description and claims as "U" shapes located along this panel, symmetrically and parallel to each other, and their depth H is 40% of the thickness G1 of core 1.

Embodiment 3

[0030] The insulating and sound-absorbing panel shown in Fig. 4 has the shape of a flattened cuboid with a length of L=2500mm, a width of S=1150mm and a thickness of G=50mm, and its core 1 is made of commonly known mineral wool with a density of 50 kg/m3, to which one surface a cladding 2 made of glass cloth is permanently attached, while under this cladding, profile grooves 7 are made on the surface of this core, having the shape of the letter "V" in the vertical cross-section and in the view from its front, located along this panel symmetrically and parallel to each other, and their depth H is 30% of the thickness G1 of core 1.

Embodiment 4

[0031] The insulating and sound-absorbing panel shown in Figures 5 and 6 has the shape of a flattened cuboid with a length of L=1800mm, a width of S=1000mm and a thickness of G=30mm, and its core 1 is a typical mineral wool with a density of 100 kg/m3, to which one a glass veil cladding 2 is permanently attached to the surface with a solvent adhesive, while under this cladding on the surface of this core cylindrical recesses 8 are made in the shape of round holes in the top view, located along this panel symmetrically and parallel to each other, and their depth H is 30% of the G1 thickness of the core 1.

Embodiment 5

[0032] The insulating and sound-absorbing panel shown in Fig. 7 and 8 has the shape of a flattened cuboid with a length of L=1500mm, a width of S=1000mm and a thickness of G=80mm, and its core 1 is a well-known mineral wool with a density of 120 kg/m3, to which one a glass veil cladding 2 is permanently attached to the surface with a solvent adhesive, while under this cladding, on the surface of this core, pairs of profile grooves 9 and 10 are made along this panel alternately and parallel to each other, and in the vertical section and the front view of this the panels of the pair of grooves 9 have U-shaped profiles, and the pairs of grooves 10 have profiles of equilateral trapezoids, while on the surfaces 11 separating these pairs of grooves 9 and 10, the core 1 on their sheathed surfaces has cylindrical recesses 12, which together with these grooves 9 and 10 have depth H, which is 50% of the thickness Gl of the core 1.

[0033] In the examples given above, the cladding can be used on both sides or on one side. The cladding can be made of canvas or glass veil, or polyester non-woven fabric or other vapor-permeable or vapor-tight membrane, depending on the application and needs.

Embodiment 6

[0034] Rectangular acoustic silencer of the absorptive type, with dimensions D: 1500mm x W: 1000mm x H:500mm. The silencer has 3 acoustic baffles, 200 mm wide, filled with mineral wool. Mineral wool with rectangular grooves in the silencer baffles was used. The grooves are transverse to the sound wave inlet. In this example, two grooved panels are connected to each other with surfaces without grooves, so that there are grooves on both sides of the baffle. You can also use a thicker panel with grooves on both sides.

[0035] Fig. 10 shows the attenuation characteristics of a simple absorption silencer for individual shapes of recesses, using slots in a transverse arrangement in relation to the direction of the inlet and outlet of the silencer. A silencer with dimensions D: 750 mm, W: 500 mm, W: 200 mm was analysed. Wool thickness in the baffle 100 mm. A one-stage silencer was tested. Similar tests were performed for the horizontal arrangement of slots. However, the arrangement of the slots transversely to the sound wave inlet provides better attenuation compared to the arrangement of the slots horizontally.

[0036] Numerical studies performed using the FEM method show the possibility of adjusting the noise suppression capabilities (tuning) of the silencer in the range of 500 and 2000 Hz octave bands.

[0037] In all embodiments of these panels, both the vertically located trapezoidal recesses 5 and the profile grooves 3, 6, 7, 9 and 10 were made with a cutter using a string plotter, and the recesses 4, 8 and 12 with a milling plotter.

[0038] Various adhesives are used in the examples, and other suitable adhesives will be used by those skilled in the art. It is important that it does not clog pores and despise suppression.

[0039] Tests were carried out to simulate the attenuation of variants of an acoustic silencer for ventilation systems made of various types of mineral wool selected for testing. The higher the attenuation in a given band, the better the noise reduction. Simulations were carried out for a rectangular absorptive silencer with dimensions D: 1500mm x W: 1000mm x H:500mm. Mineral wool with grooves in the silencer baffles was used. The grooves were located transversely

along the height of the silencer. Simulation based on the FEM method. Four types of mineral wool were tested: Rockwool INDUSTRIAL BATTS BLACK 69 (WM-R-60), PAROC InVent 60 N3 (WM-P-60), ISOVER TECH Slab MT 4.1/ ISOVER PT80 (WM-I_80), ROCKWOOL ProRox SL 960 EN (TECHROCK 100) (WM-R-100). To compare a silencer with panels with recesses and a typical silencer, a silencer with panels without recesses was also modeled. The results are shown in Table 1. The modeling results for the traditional silencer are shown in the column Validation - FEM. noise. Simulations were carried out for a rectangular absorptive silencer, with dimensions D:1500mm x W:1000mm x H:500mm. Wool was used mineral with grooves in the silencer baffles. The grooves were transversely after silencer height. Simulation based on the FEM method. Four types of wool were tested mineral: Rockwool INDUSTRIAL BATTS BLACK 69 (WM-R-60), PAROC InVent 60 N3 (WM-P-60), ISOVER TECH Slab MT 4.1/ ISOVER PT80 (WM-I_80), ROCKWOOL ProRox SL 960 PL (TECHROCK 100) (WM-R-100). To compare a containing silencer panels with recesses with a typical silencer, a silencer with panels was also modeled without choice. The results are presented in Table 1. Traditional modeling results of the silencer are shown in the column Validation - FEM.

Table 1.

Octave band [Hz]	Attenuation [dB]				
	Validation - FEM	WM-R-60	WM-P-60	WM-I-80	WM-R-100
63	2,45	1,08	1,06	1,25	1,87
125	8,92	6,11	5,66	5,81	5,79
250	23,51	27,62	26,22	23,36	16,01
500	40,76	66,52	59,41	56.98	53.55
1000	54,77	67.54	64.81	66.81	73,64
2000	58,63	49,41	52.91	52,03	47,91
4000	35.54	24,49	29.82	34,43	37,32

[0040] The comparison in table 1 shows that the attenuation in some octave bands is better for silencers with hollow mineral wool panels.

[0041] Evaluation of the results allows the indication of WM-P-60 (PAROC InVent) and WM-I-80 (ISOVER TECH Slab MT 4.1 as the optimal acoustic materials among surveyed.

[0042] For the same materials and the same construction of the damper, vibration tests were performed using the FEM methodology. And in this case, the materials WM-P-60 (PAROC InVent) and WM-I-80 (ISOVER TECH Slab MT 4.1) turned out to be the most beneficial, achieving a vibration reduction of 10%.

[0043] Laboratory tests of transmission damping and dropout damping were also carried out for dampers of the same design, containing mineral wool panels without recesses WM-P-60-BW and panels with recesses WM-P-60. The results are shown in Table 2 - transfer damping comparison and Table 3 - precipitation damping comparison.

Table 2

	WM-P-60-8W	WM-P-60
f	D_{t5}	
[Hz]	[dB]	
63	15.5	13.4
125	11.2	10.2
250	19.6	18.6
500	30.9	36.6
1000	41.6	44.9
2000	36.6	35.1
4000	22.7	23.5

Table 3

	WM-P-60-8W	WM-P-60
f	D_{t5}	
[Hz]	[dB]	
63	10.5	9.8
125	10.6	10.2
250	17.9	17.3
500	30.4	36.8
1000	41.8	44.9
2000	38.0	35.7
4000	24.6	24.9

[0044] In the case of transfer damping and dropout damping, there is an analogous relationship. The WM-P-60 attenuator with a panel with recesses is characterized by significantly better attenuation in the 500 Hz and 1000 Hz bands.

[0045] The invention is used for thermal and acoustic insulation of ventilation ducts, plenum boxes, filling gap acoustic silencers, ventilation silencers, screens, screen absorption silencers, sound-absorbing panels and as internal acoustic insulation in industrial and ventilation devices.

Claims

1. A silencing and sound absorbing panel made of a fibrous material, preferably mineral wool, **characterized in that** it has many recesses (3, 6, 7, 8, 9, 10, 12), the depth of which (H) is 30-60% of its thickness (G1) and on at least one surface it includes a cladding (2) made of glass veil or glass fabric or canvas or polyester non-woven fabric or a vapor-permeable or vapor-tight membrane.

2. The panel according to claim 1, **characterized in that** the recesses are on one side of the panel.

3. The panel according to claim 1, **characterized in that** its recesses (3) are vertically and symmetrically located trapezoidal grooves (4), the lower ends of which are connected with round cutouts (5) located horizontally along the panel (1).

4. The panel according to claim 1, **characterized in that** the profile recesses (6) in the vertical section have the shape of the letter "U" and are located along this panel and symmetrically and parallel to each other.

5. The panel according to claim 1, **characterized in that** the profile recesses (7) in the vertical section have the shape of the letter "V" and are located along this panel and symmetrically and parallel to each other.

6. The panel according to claim 1, **characterized in that** it has a plurality of vertical cylindrical recesses (8).

7. The panel according to claim 1, **characterized in that** it has pairs of recesses (9 and 10) located alternately and symmetrically and parallel to each other, the pairs of recesses (9) in the vertical section have U-shaped profiles, and the pairs of recesses (10) have profiles of equilateral trapezoids, and between these recesses (9 and 10) there are vertical cylindrical recesses (12) of the same depth (H) as the recesses (9 and 10).

8. An acoustic silencer comprising acoustic baffles, **characterized in that** the acoustic baffles are filled with a panel according to claim 1, wherein the panel made of fiber, preferably mineral wool, has many recesses (3, 6, 7, 8, 9, 10, 12), whose depth (H) is 30-60% of its thickness (G1).

9. Silencer according to claim 8, **characterized in that** the recesses (3, 6, 7, 9, 10, 12) extend transversely to the inlet of the silencer.

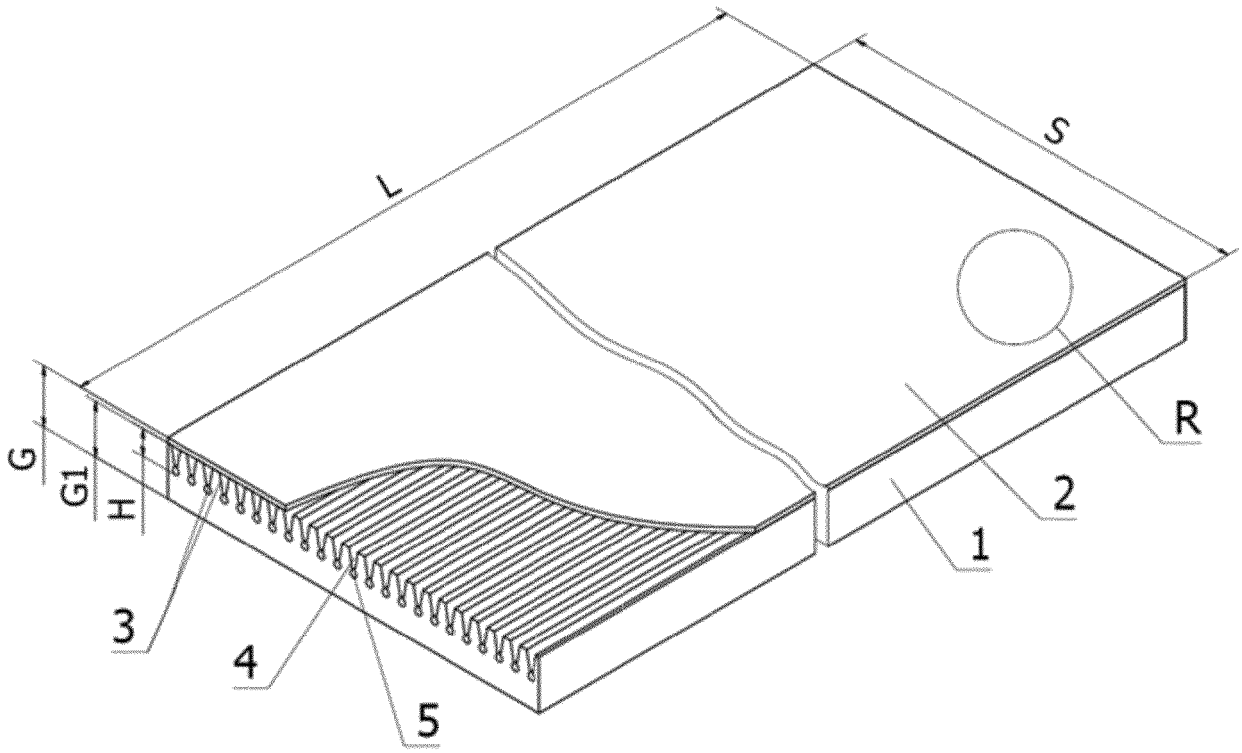


Fig. 1

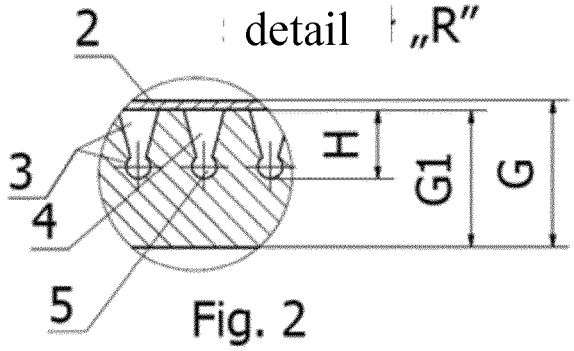


Fig. 2

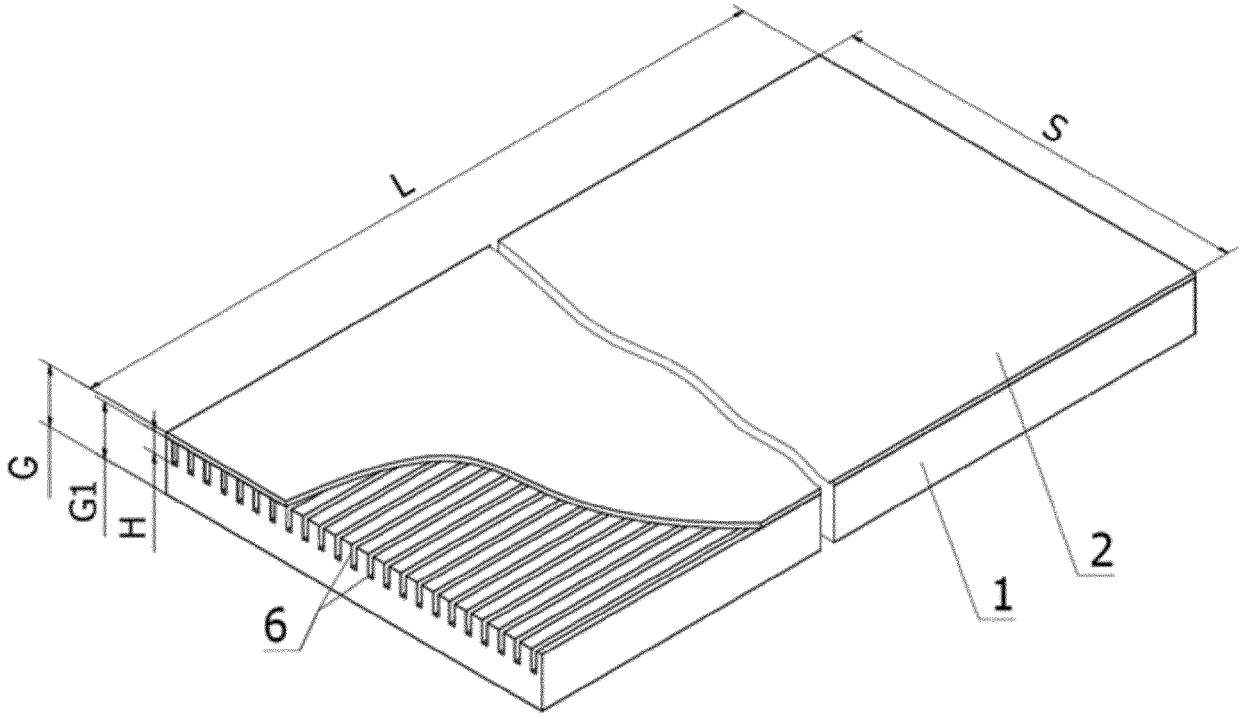


Fig. 3

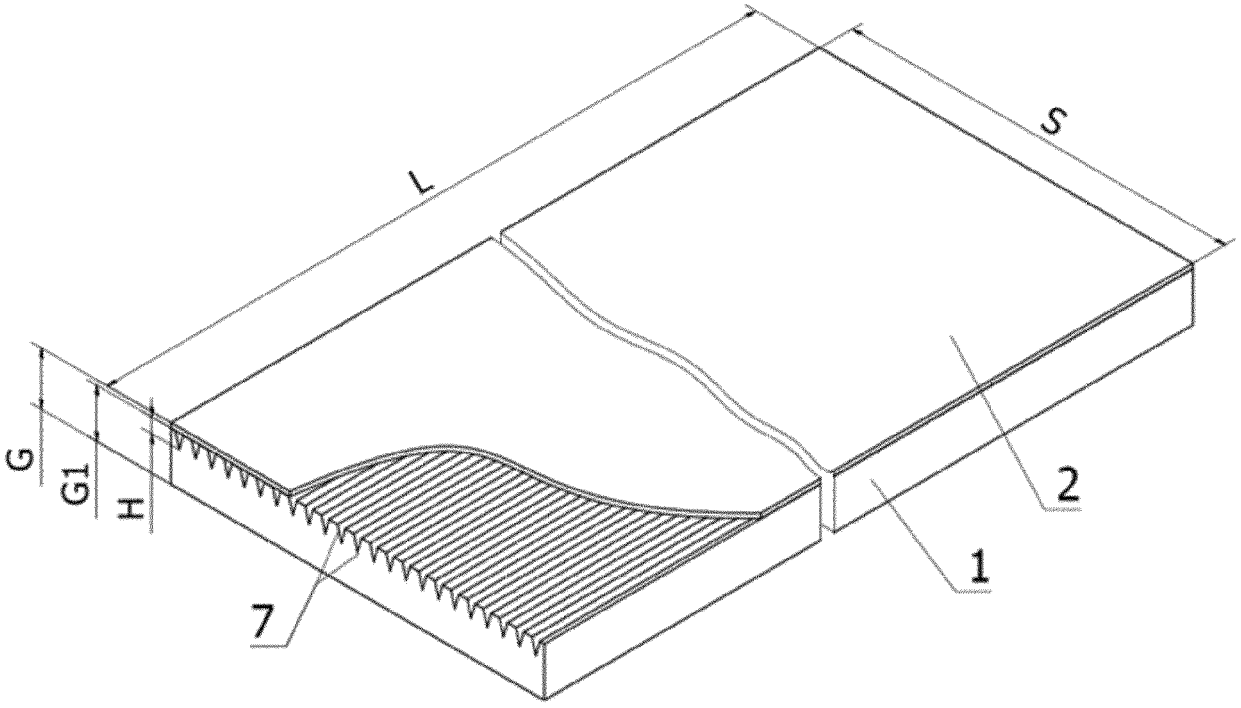


Fig. 4

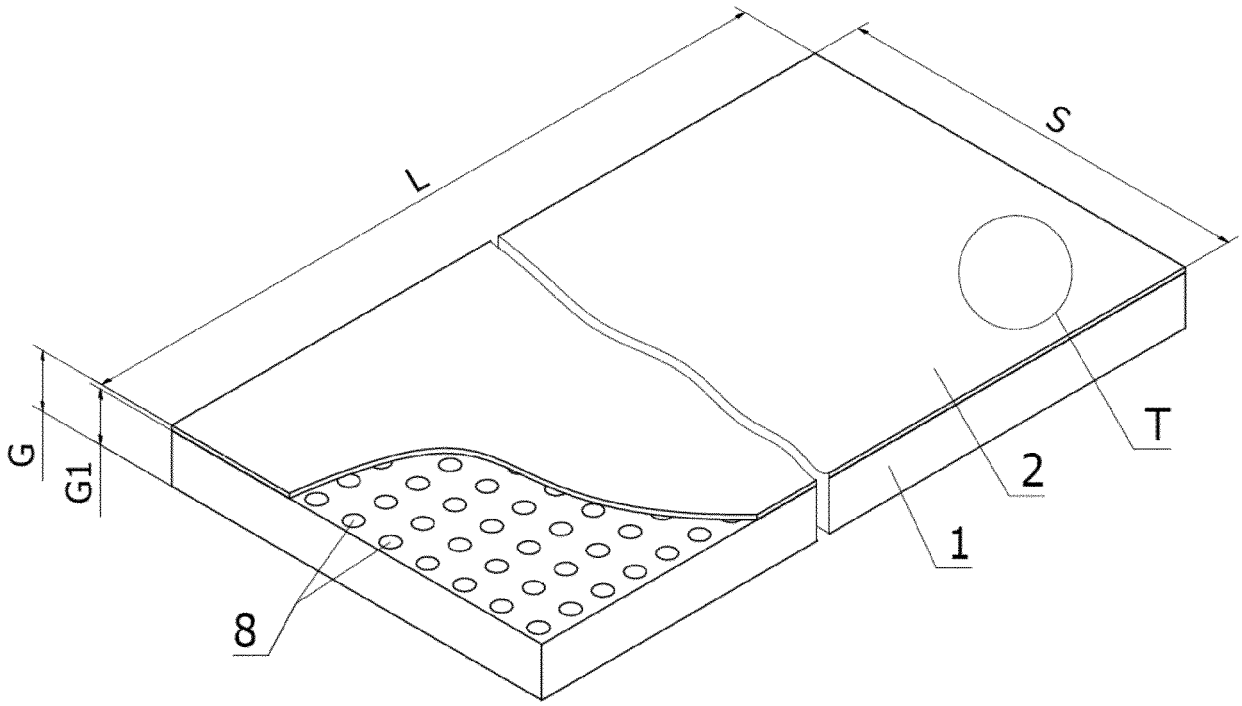


Fig. 5

detail „T"

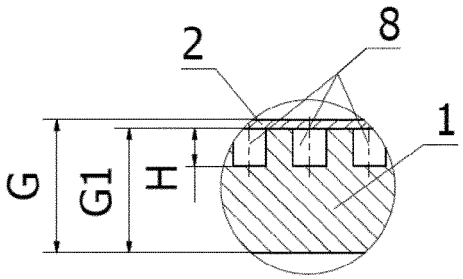


Fig. 6

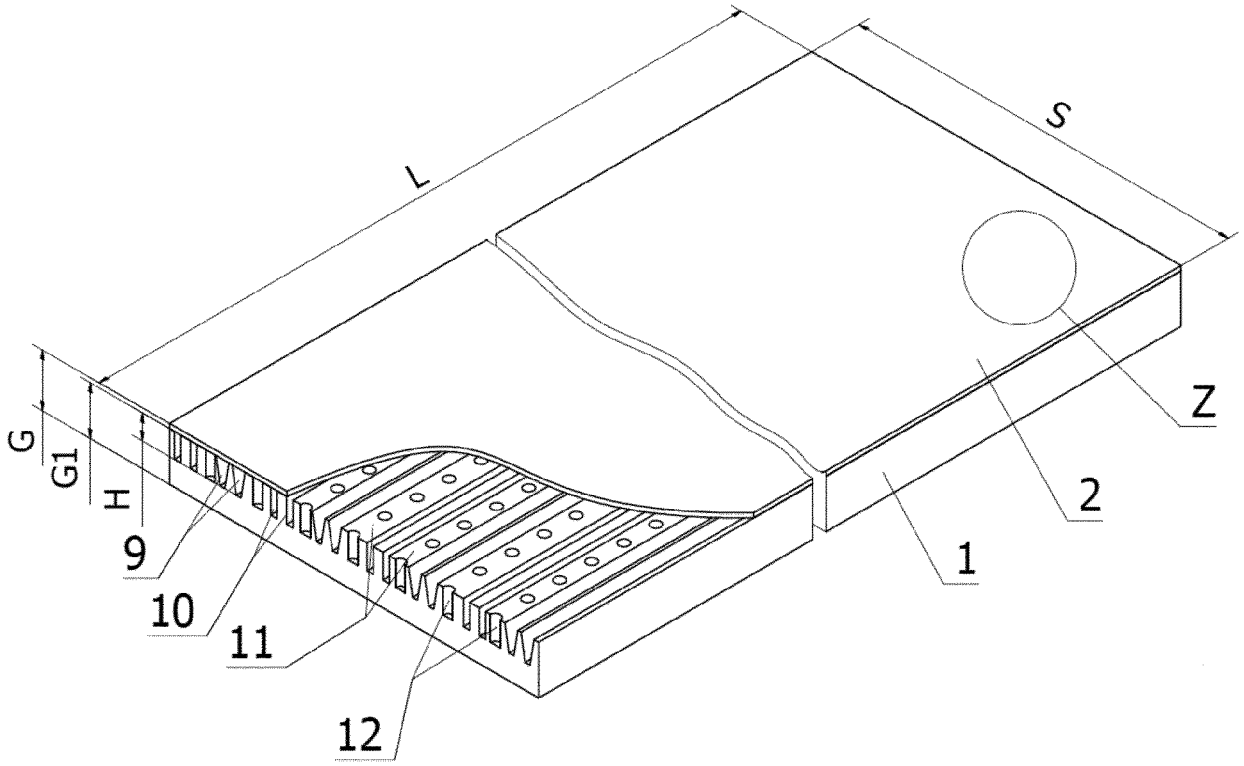


Fig. 7

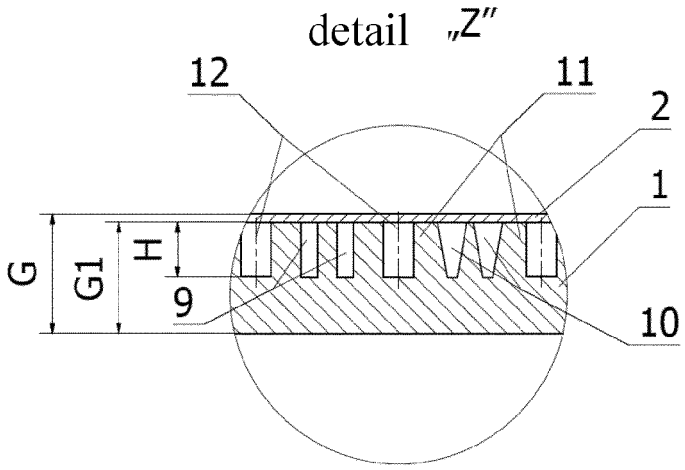


Fig. 8

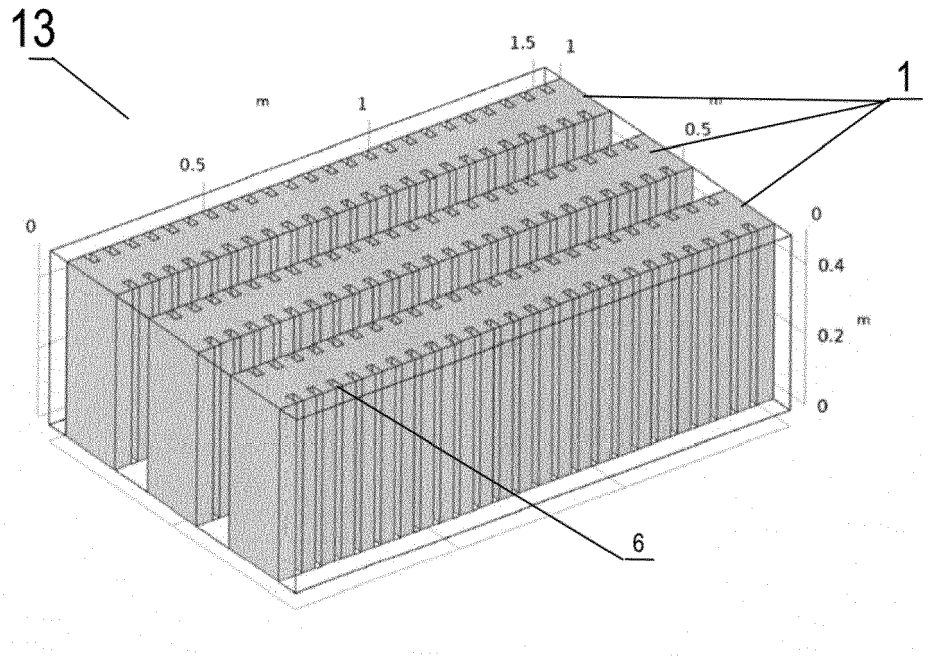
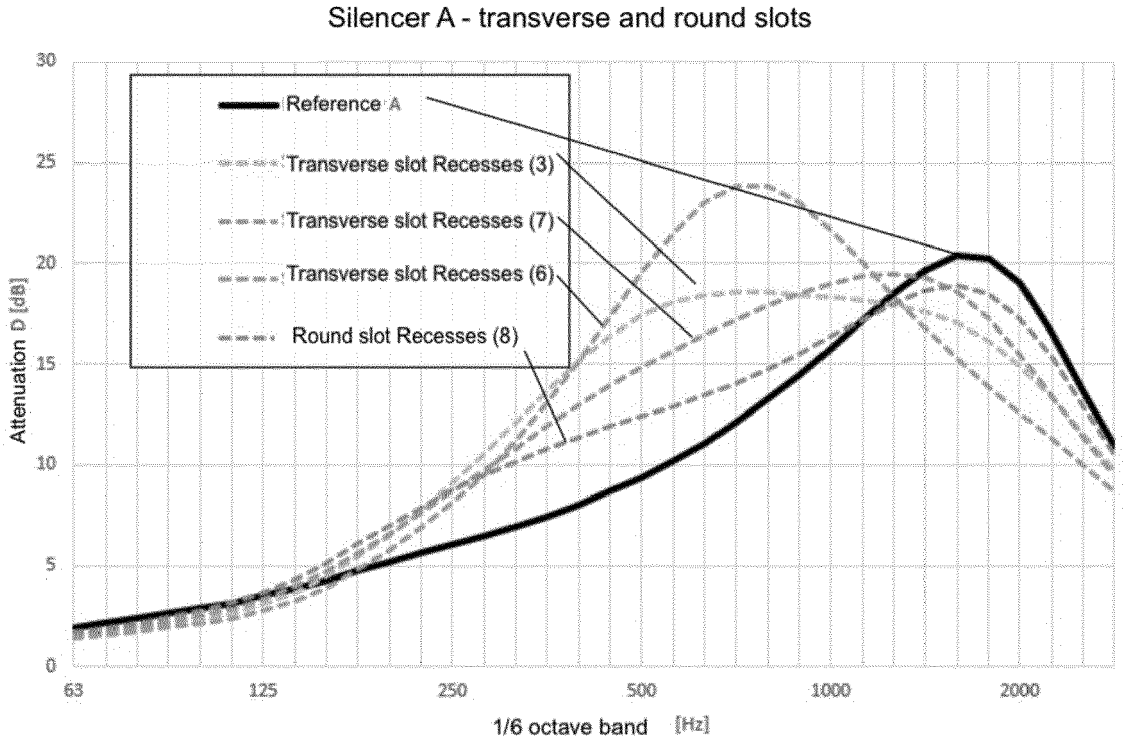


Fig. 9


Silencer A - transverse and round slots
Reference A
Transverse slot Recesses (3)
Transverse slot Recesses (7)
Transverse slot Recesses (6)
Round slot Recesses (8)
Attenuation D [dB]
30
25
20
15
10
5
0
63
125
250
500
1000
2000
1/6 octave band [Hz]

Europäisches Patentamt
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EUROPEAN SEARCH REPORT

Application Number
EP 22 21 4937

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	GB 2 157 337 A (ICI PLC) 23 October 1985 (1985-10-23) * page 1, line 5 - page 2, line 3; figure 1 *	1-9	INV. E04B1/86 ADD. E04B1/84
X	GB 946 423 A (HOWARD ARNOLD GARROOD) 15 January 1964 (1964-01-15) * page 1, line 1 - line 59; figures 1-2 *	1-9	
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A	* page 1, line 3 - page 3, line 17; figures 1-3 *	8,9	
A	US 5 869 792 A (ALLEN DONALD L [CA] ET AL) 9 February 1999 (1999-02-09) * column 2, line 11 - column 7, line 45; figures 1-15 *	8,9	

TECHNICAL FIELDS SEARCHED (IPC)

E04B
F16L
F24F

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	3 August 2023	Dieterle, Sibille

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 22 21 4937

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03-08-2023

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REFERENCES CITED IN THE DESCRIPTION

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