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(54) Title: ACOUSTIC BARRIER

(57) Abstract: The invention concerns an acoustic barrier between a space with a noise source and a noise receiving space and its subject matter consists in a barrier (1) consisting of a thin plate with both the radii of curvature of a finite size and the same sign. Barrier (1) is equipped with at least one rib (10) of a closed or an open shape. Ribs (10) consist of thin plates with both the radii of curvature of a finite size and the same sign, whereas a thickness of barrier (1) is equal or less than a thickness of ribs (10).

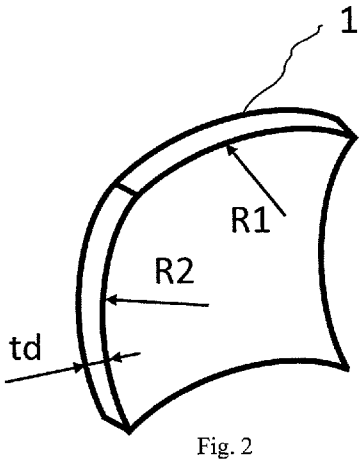

Fig. 2

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Acoustic Barrier

Technical Field of the Invention

The invention concerns an acoustic barrier between a space with a noise source and a noise receiving space.

State-of-the-art

Today's barriers between spaces where a noise source is and areas where there are people with a need of reduced noise are mostly designed by choosing a material with a different absorption capacity. Their shape is not selected systematically. In many cases an outer shape of the space is cylindrical, which increases the acoustic energy radiation on surface straight lines. If barriers consist of thin plates and are reinforced by ribs, then, for production reasons, the ribs will have planar transitions, thus increasing the acoustic energy radiation.
The aim of this invention is a device for reduction of noise transfer through a barrier, a design of which is based on structural elements with a lower radiation of acoustic energy applicable for any material.

Subject Matter of the Invention

A subject matter of an acoustic barrier between a space with a noise source and a noise receiving space according to the invention consists in an acoustic barrier consisting of a thin plate with both the radii of curvature of a finite size and the same sign. The acoustic barrier is equipped with at least one rib of a closed or an open shape. Ribs consist of thin plates with both the radii of curvature of a finite size and the same sign. The ribs can be of an oval shape or arranged side by side or concentrically or they can be arranged in layers one above the other, they can be equipped with openings between spaces of adjoining ribs or spaces of ribs and additional ribs. A thickness of the acoustic barrier is equal or less than a thickness of the ribs. A sound insulation material is inside the ribs and/or additional ribs.

Overview of Figures in Drawings

A subject matter of an acoustic barrier between a space with a noise source and a noise receiving space is schematically depicted in the attached Figures, where
Fig. 1 shows a general arrangement of a noise barrier between two spaces
Fig. 2 shows a particular barrier, or to be precise its part
Figs. 3 to 20 show alternative embodiments of a barrier equipped with ribs

Examples of Embodiments of the Invention

Fig. 1 shows a general typical arrangement of a noise transfer (acoustic energy) between two spaces. Noise also comprises vibrations and harshness (NVH = noise, vibration, harshness) and

sound. Space 4 with noise source 2 is separated from space 5 with noise receiver 3 by acoustic barrier 1. The purpose of acoustic barrier 1 is to reduce the noise transfer from space 4 into space 5. An example of noise source 2 can be e.g. a combustion engine in a car or a plane and noise receiver 3 is a driver or a passenger. Acoustic barrier 1 is a car dashboard or a plane fuselage. Noise source 2 can also be a combustion engine cylinder and noise receiver 3 is a car engine space and acoustic barrier 1 is an engine head cover.

A solution of an acoustic barrier according to this invention is based on the knowledge that planar surfaces (have infinite radii of curvature) radiate the acoustic energy more than curved surfaces (a finite radius of curvature) and surfaces containing straight lines (one infinite radius or radii of curvature with a different sign) radiate the acoustic energy more than surfaces not containing straight lines (radii of curvature with the same sign). So cylindrical, conical and straight surfaces are unsuitable. Thin-walled structures radiate acoustic energy less than thick-walled ones because they are lighter and contain mass points (given by an assumed cutout of a structure) with a lower weight. A thin-walled structure can have problems with the structure stability and a deformation under loading, therefore it is equipped with reinforcing ribs.

Fig. 2 shows a solution of an acoustic barrier, where acoustic barrier 1 consists of a thin plate with a thickness td, the boundary surface of which has both main curvatures R1 and R2. R1 curvature with R1 curvature radius and R2 curvature with R2 curvature radius are finite sizes with the same sign. The noise transfer will be reduced, if acoustic barrier 1 is as thin as possible, this means td thickness is as small as possible, and acoustic barrier 1 is not planar, so both the curvatures are of a finite size, and does not contain straight lines, so both the curvatures are of the same sign.

Acoustic barrier 1 is considered thin, when its td thickness 9 is not more than 0.1 of the plate dimension (a length or a width) or 0.1 of R1 or R2 radius of curvature.

Acoustic barrier 1 consists of a thin "stamped" plate. The plate is a material object between two (exactly or approximately) equidistant surfaces and the plate curvature is a curvature of a boundary surface of the plate.

Fig. 3 shows a thin plate as depicted in Fig. 1 equipped with a rib (ribs) 10 of a thickness tz, so that its strength and structure stability could withstand the thinness.

Fig. 4 shows an example, where acoustic barrier 1 is equipped with two ribs 10.

Fig. 5 and next Figs. 6-12 show schematic depictions of various arrangements of different numbers of ribs 10. Fig.5 shows two rectangular ribs 10, Fig. 6 shows more rectangular ribs 10, Fig. 7 shows skew ribs 10, Fig. 8 shows polygonal ribs 10, in this case hexagonal ones, Fig. 9 shows oval (elliptical) ribs 10 and Fig. 10 shows curvilinear ribs 10 as a closed curve, Fig. 11 shows curvilinear ribs 10 consisting of more open curves. Fig. 12 shows oval (elliptical) ribs 10 that are nested one into another. Since ribs 10 are also excited acoustically, they can radiate noise.

Therefore it is applicable that ribs 10 should also be thin and have the both main curvatures of a finite size and the same sign.

A perfect embodiment of ribs 10 is shown in Fig. 9 and Fig. 12, because ribs 10 in a projection have a curvature of the same sign. Fig. 13 and 14 show the second curvature of ribs 10 of the same sign. In the projection on the right-hand side in Figs. 13 and 14 ribs 10 have a curvature of one sign and perpendicular to the plate of acoustic barrier 1 in the projection on the left-hand side in the Figure they have a curvature of the same sign as in the projection on the right-hand side.

Fig. 15 shows a solution of acoustic barrier 1 with rib 10, which is closed and have curvatures of a finite size and the same sign. If rib 10 is closed, it will be structurally more stable and can be lighter. Thinner rib 10 radiates less acoustic energy.

Fig. 16 shows a solution of acoustic barrier 1 with ribs 10, which is closed and have curvatures of a finite size and the same sign. Ribs 10 cover the whole acoustic barrier 1 or its large part. It is similar to the embodiment depicted in Fig. 8 but ribs 10 are closed and have curvatures of a finite size and the same sign.

Fig. 17 shows a solution of acoustic barrier 1 with ribs 10, which are covered with additional ribs 12. Additional ribs 12 are connected to rib/ribs 10 or other additional rib/ribs 12.

In this case ribs 10 are separately connected to acoustic barrier 1 and additional ribs 12 are not connected to acoustic barrier 1. The advantage is that ribs 10 or additional ribs 12 can be both thin-walled, thus radiating less acoustic energy, and can form other barriers to prevent further noise propagation.

Fig. 18 shows a similar solution of the acoustic barrier as depicted in Fig. 17. Additional ribs 12 connect acoustic barrier 1 to rib 10. Only the next layer of additional ribs 12 is connected only to foregoing additional ribs 12. In addition, inside closed additional rib 12 there is acoustic insulation material filler 6, which can be e.g. foam, cotton-wool, loose material, granules, particles. This filler can be inside other or all or only some ribs 10 and/or 12. This filler can fill the entire rib space or only its part.

Fig. 19 shows a similar embodiment as depicted in Fig. 18, where rib 10 and/or additional ribs 12 include a various number of openings 13. Openings 13 are positioned side by side or they are separated by attachments of other ribs 10 or 12. The advantage is that openings 13 transmit sound, which is then muffled by an interaction with the inner space inside other additional rib 12. Other open ribs can also be inside ribs 10 or 12, for example as depicted in Figs. 13 and 14.

Fig. 20 shows an embodiment of acoustic barrier 1, which is closed, for example a plane fuselage, a crew cockpit or, on the other hand, an engine space. There is a longitudinal and transverse section depicted. Acoustic barrier 1 is thin and has curvatures of a finite size and the same sign. Closed acoustic barrier 1 in Fig. 20 has a shape significantly different from a cylinder.

It can be reinforced with ribs 10 and additional ribs 12. These ribs can cover whole acoustic barrier 1.

Ribs 10 and 12 in certain embodiments have a form of a "honeycomb".

The advantage of the described invention is a possibility to reduce a noise transfer between two spaces using a barrier. A subject matter is to create a thin-walled acoustic barrier in a shape of a thin plate with curvatures of a finite size and the same sign. The plate is as thin as possible and its strength and structure stability is solved by ribs. Ribs are thin and also have curvatures of a finite size and the same sign. A surface of each rib 10, 12 is significantly less than a surface of acoustic barrier 1.

The greater the curvature and lesser thickness and lesser surface, the less radiated acoustic energy passes through the barrier or the rib.

Inside closed ribs 10 or 12 there can be acoustic insulation material filler 6, which can be e.g. foam, cotton-wool, loose material, granules, particles. Loose material, which does not fill the rib inner space completely, starts to move by acoustic energy acting and the acoustic energy becomes muffled by effect of mutual friction of the particles. Sand can be an example.

All variants described above can be combined in various number one with another. The device can be made of any material. 3D print is an advisable manufacturing technology that enables to make ribs with finite curvatures and closed ribs.

Patent Claims

1. An acoustic barrier between a space with a noise source and a noise receiving space, characterized in that barrier (1) consists of a thin plate with both the radii of curvature of a finite size and the same sign.

2. An acoustic barrier according to Claim 1, characterized in that barrier (1) is equipped with at least one rib (10) of a closed or open shape.

3. An acoustic barrier according to Claim 2, characterized in that ribs (10) and/or additional ribs (12) consist of thin plates with both the radii of curvature of a finite size and the same sign.

4. An acoustic barrier according to Claims 2 and 3, characterized in that ribs (10) are of an oval shape and arranged side by side or concentrically.

5. An acoustic barrier according to Claims 2 and 3, characterized in that ribs (10) and/or additional ribs (12) are arranged in layers one above the other.

6. An acoustic barrier according to Claim 5, characterized in that ribs (10) and/or additional ribs (12) are equipped with openings (13) between spaces of adjoining ribs (10) or spaces of ribs (10) and additional ribs (12).

7. An acoustic barrier according to Claims 2 and 3, characterized in that a thickness of barrier (1) is equal or less than a thickness of ribs (10).

8. An acoustic barrier according to Claims 2 and 3, characterized in that sound insulation material (6) is placed inside ribs (10) and/or additional ribs (12).

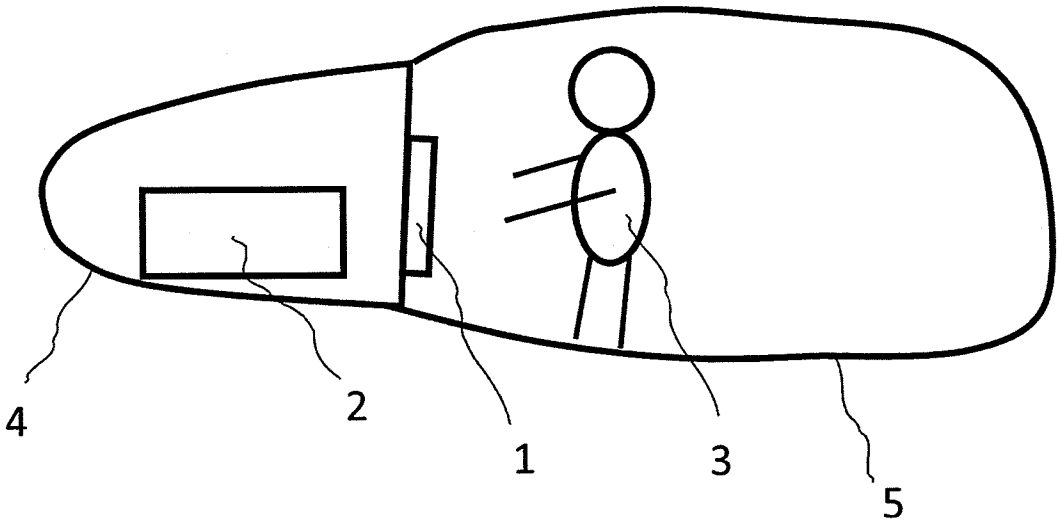

Fig. 1

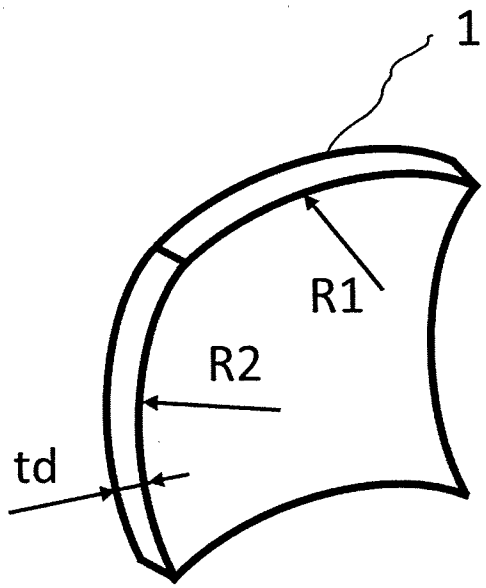

Fig. 2

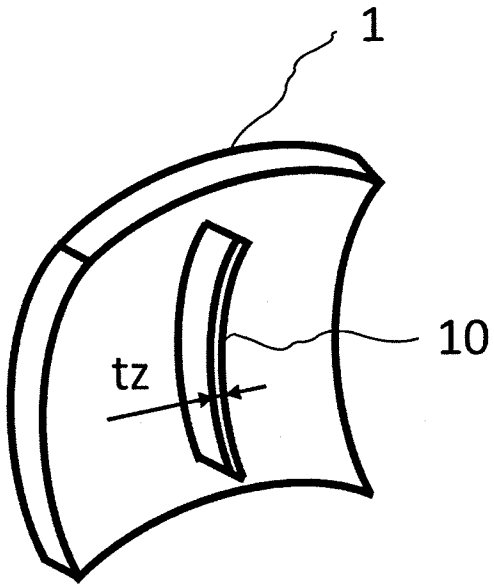

Fig. 3

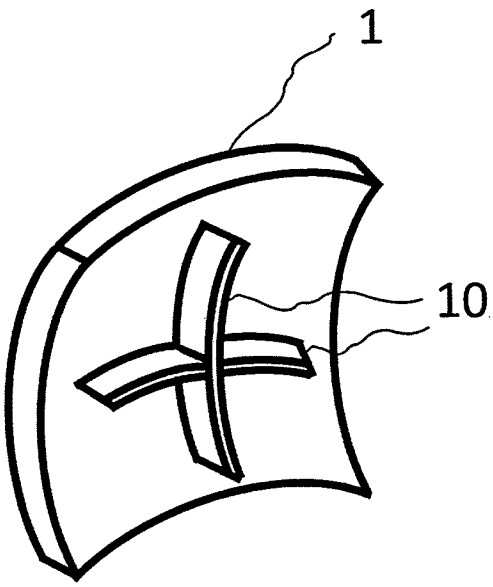

Fig. 4

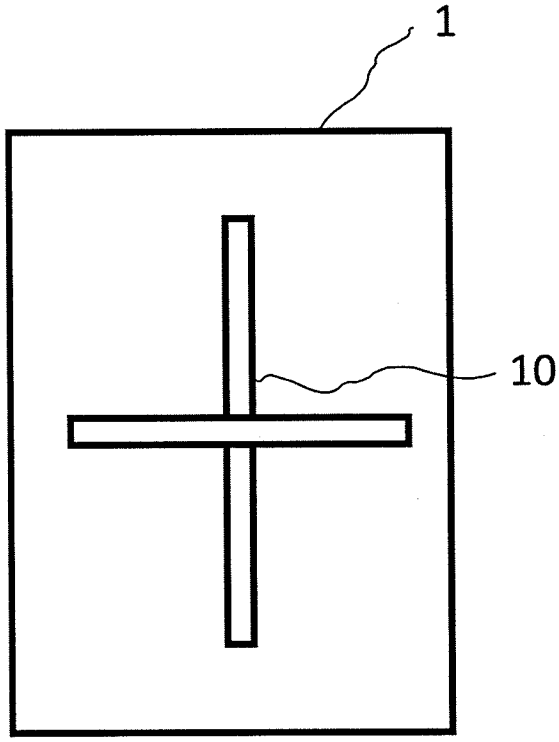

Fig. 5

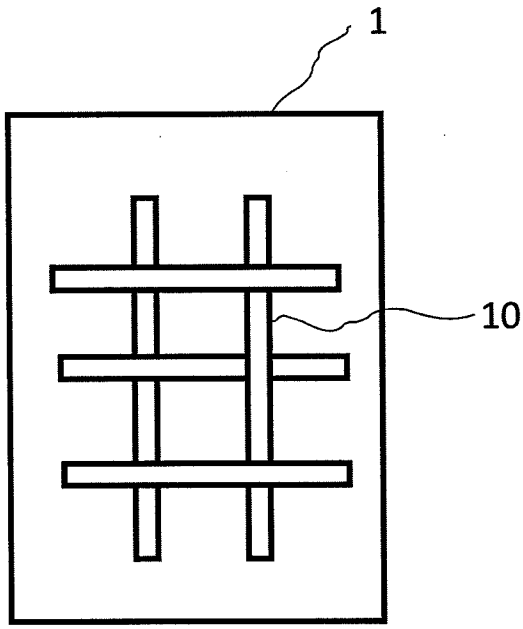

Fig. 6

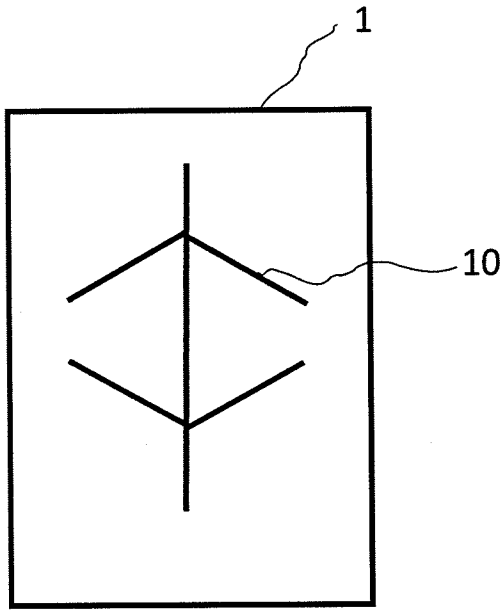

Fig. 7

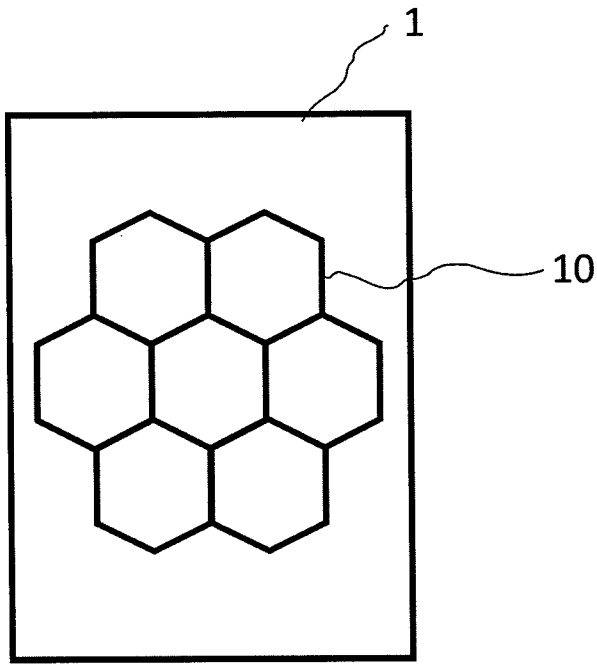

Fig. 8

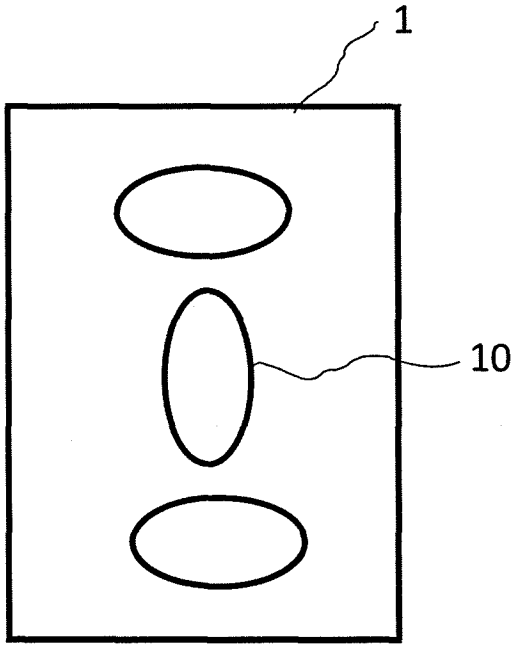

Fig. 9

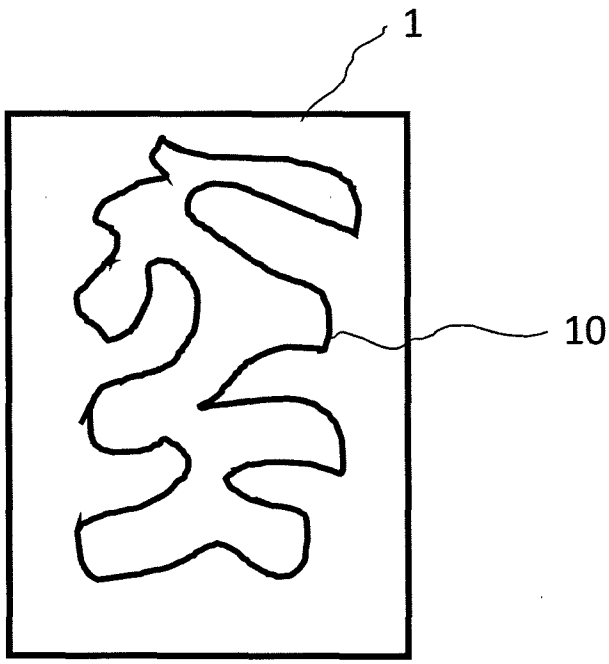

Fig. 10

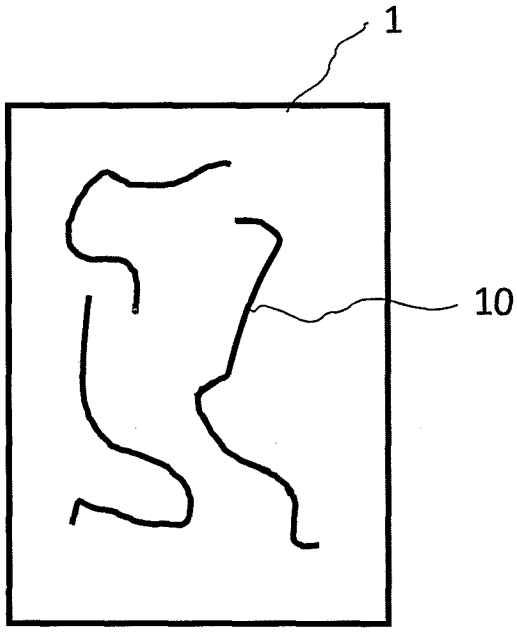

Fig. 11

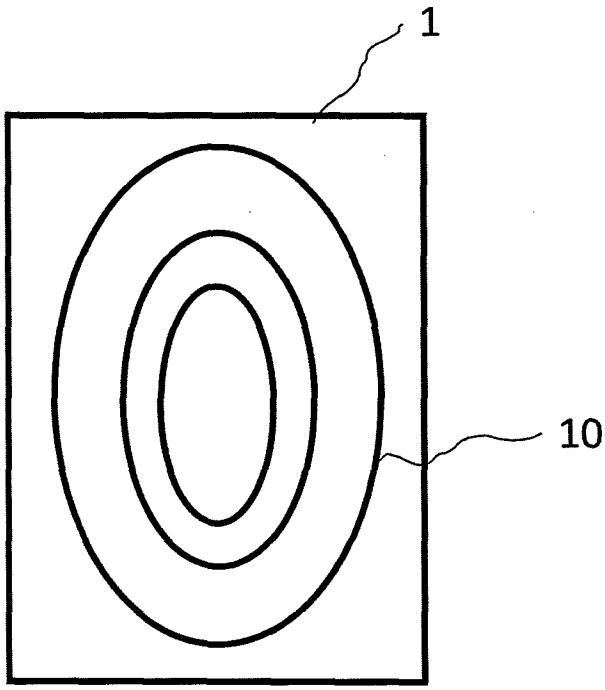

Fig. 12

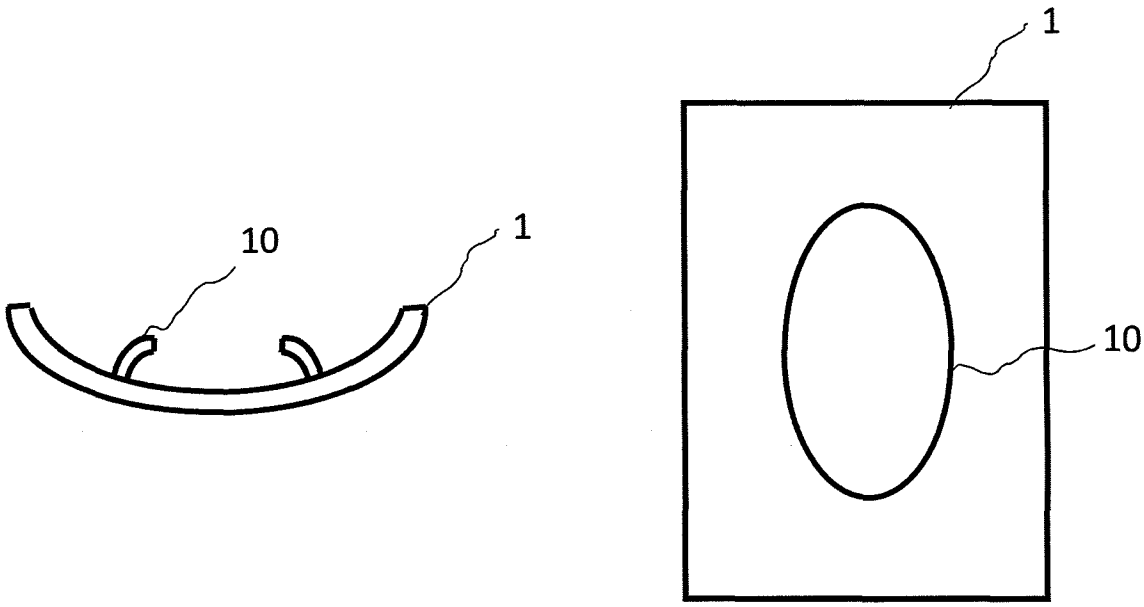

Fig. 13

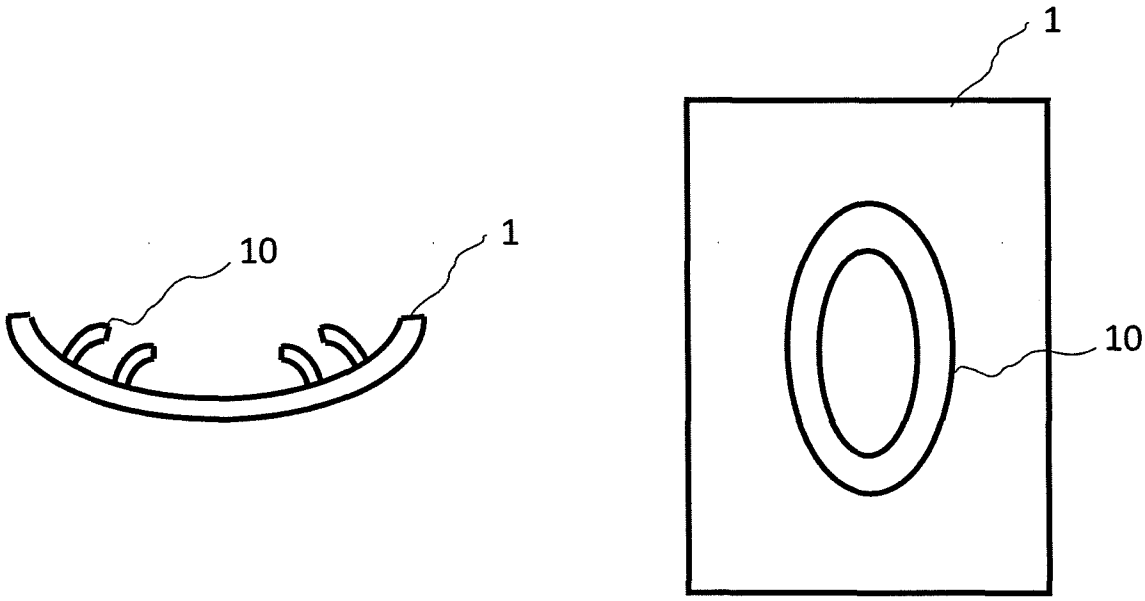

Fig. 14

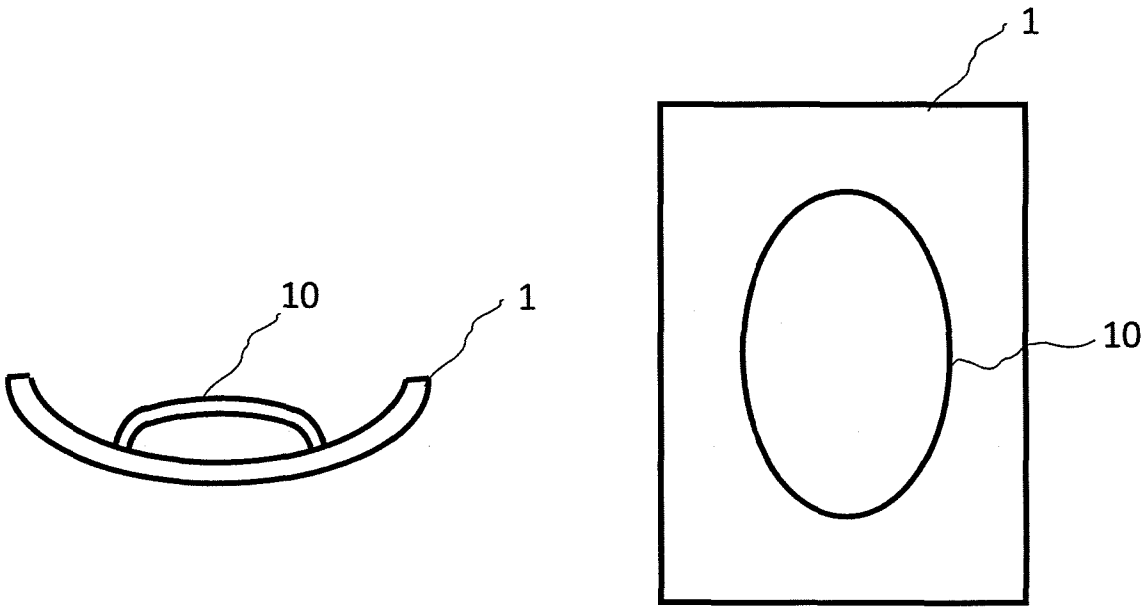

Fig. 15

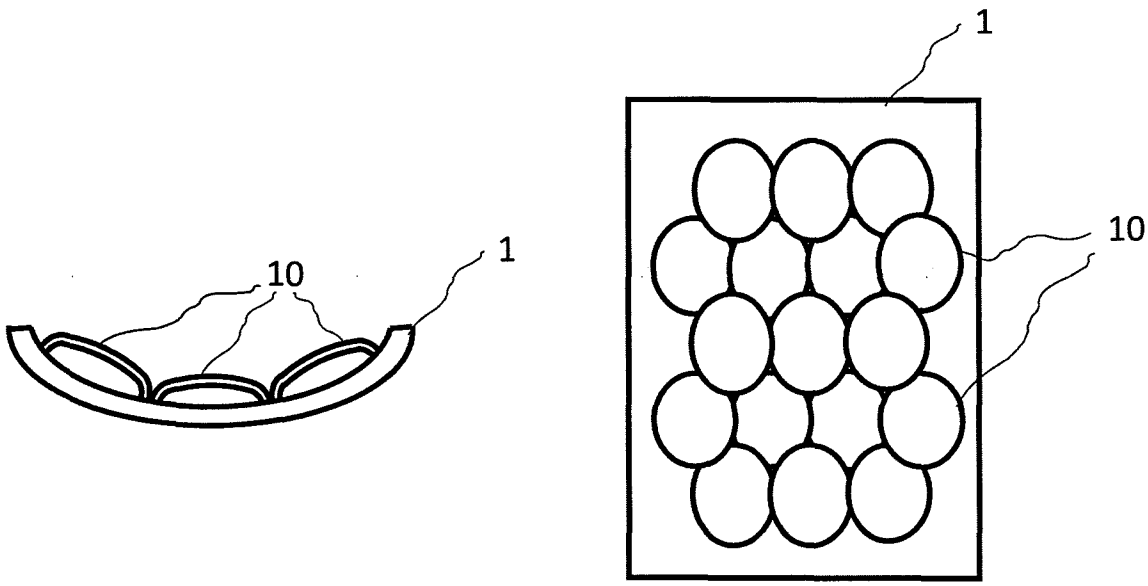

Fig. 16

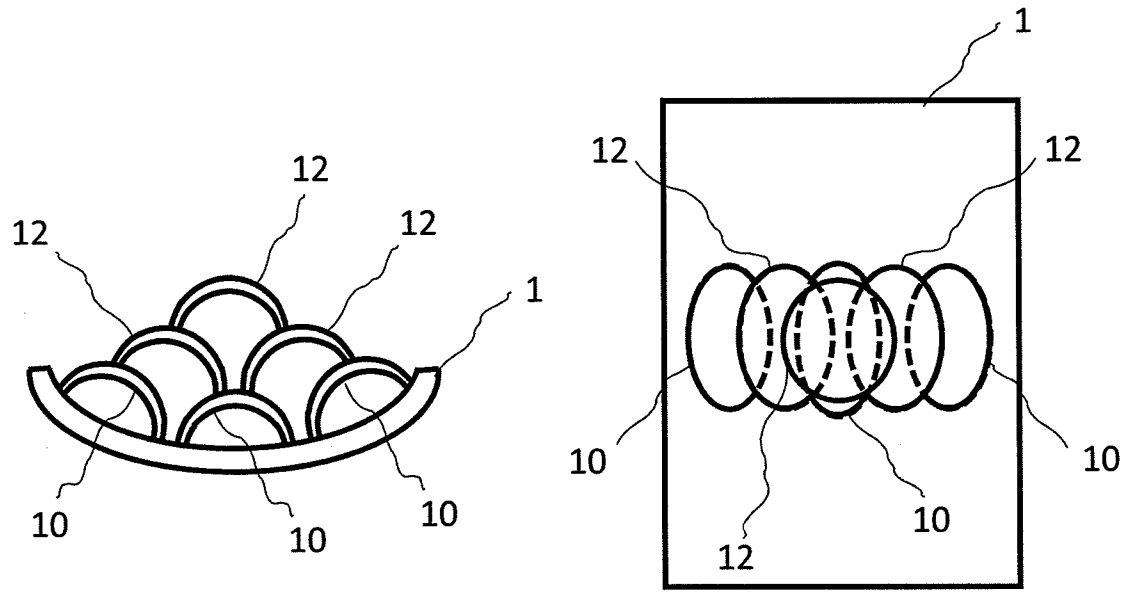

Fig. 17

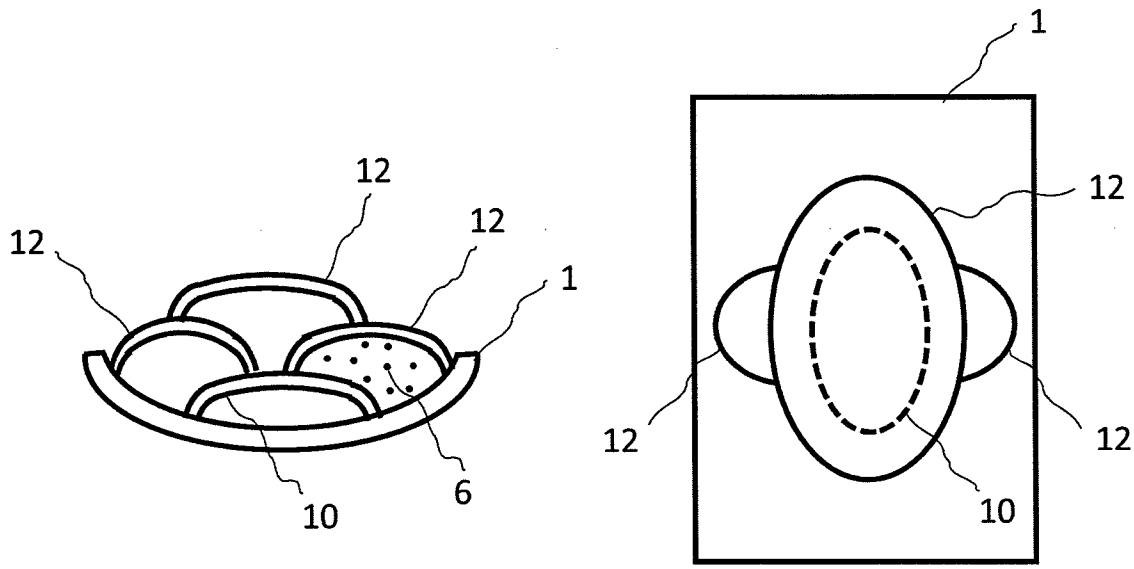

Fig. 18

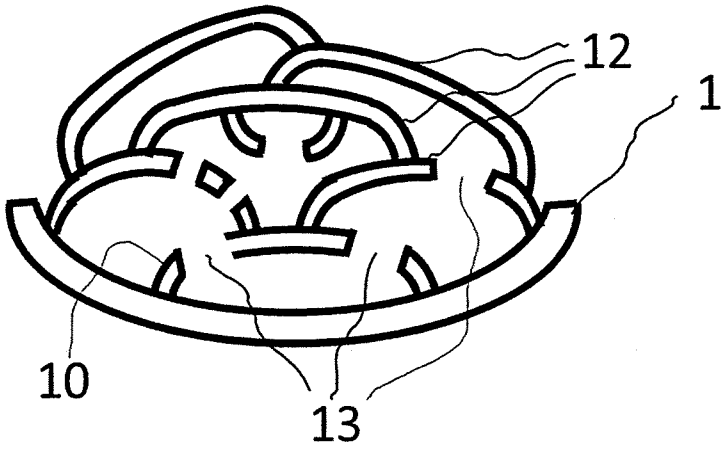

Fig. 19

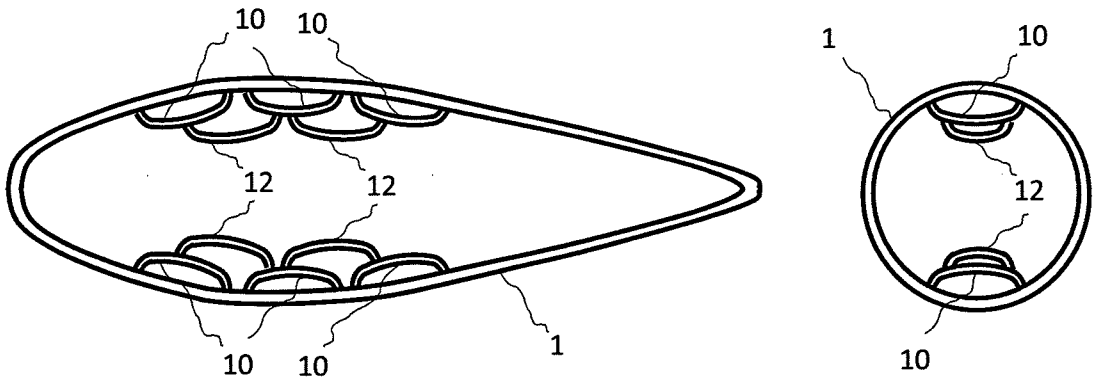

Fig. 20

INTERNATIONAL SEARCH REPORT

International application No
PCT/CZ2021/000053

A. CLASSIFICATION OF SUBJECT MATTER
INV. G10K11/16 E04B1/84
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
G10K E04B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2021/039349 A1 (GURVICH MARK R [US] ET AL) 11 February 2021 (2021-02-11)	1-3
Y	paragraph [0046] - paragraph [0052]	4,5,8
A	figures 1C, 2-4	6

X	US 2018/354430 A1 (DOMINGUEZ DAVID [DE]) 13 December 2018 (2018-12-13)	1-3,7
Y	claim 1	4,5,8
A	paragraph [0015] figures 1A, 1B	6

X	US 2002/104288 A1 (O'SULLIVAN DONALD Q [US] ET AL) 8 August 2002 (2002-08-08) paragraph [0068] paragraph [0081] figure 5	1

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[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

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"X" document of particular relevance;; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
10 February 2022	22/02/2022

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Tympel, Jens

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Form PCT/ISA/210 (second sheet) (April 2005)

INTERNATIONAL SEARCH REPORT

International application No
PCT/CZ2021/000053

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	GHASSABI M ET AL: "Investigation of state vector computational solution on modeling of wave propagation through functionally graded nanocomposite doubly curved thick structures", ENGINEERING WITH COMPUTERS, SRPINGER UK, GB, vol. 36, no. 4, 21 May 2019 (2019-05-21), pages 1417-1433, XP037256298, ISSN: 0177-0667, DOI: 10.1007/S00366-019-00773-6 [retrieved on 2019-05-21] abstract figures 1, 3	1
X	EP 0 706 596 B1 (SOLOMON INVEST GROUP LTD [VI]) 29 May 2002 (2002-05-29) paragraph [0007] figure 10 paragraph [0054]	1
X	US 10 436 118 B2 (ROHR INC [US]) 8 October 2019 (2019-10-08) figure 2 column 4, line 16 - line 46	1
X	US 2019/088242 A1 (TANG LARRY [US] ET AL) 21 March 2019 (2019-03-21) figures 1A-2 paragraph [0008]	1
Y	US 9 222 229 B1 (CHANG CHIA-MING [US] ET AL) 29 December 2015 (2015-12-29) figure 7D column 8, line 60 - line 65	4
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INTERNATIONAL SEARCH REPORT

Information on patent family members

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