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(54) ACOUSTIC DEVICE, IN PARTICULAR FOR APPLICATIONS IN THE AUTOMOTIVE INDUSTRY

(57) An acoustic device (1) for applications in the automotive industry provided with a microphone device (3) connected to a support (2) and having a sensitive area (5); an acoustic conduit (10) designed to convey the sound pressure waves generated by an external acoustic source towards the sensitive area (5); a membrane (15) interposed between the microphone device (3) and the terminal portion (12) of the acoustic conduit (10); a grid (20) made of a metal material and arranged along the acoustic conduit (10) to protect the membrane (15) from the collision with possible bodies, which might enter the acoustic conduit (10), and to dissipate the energy of a pressurized fluid jet, which is incident on the device (1).

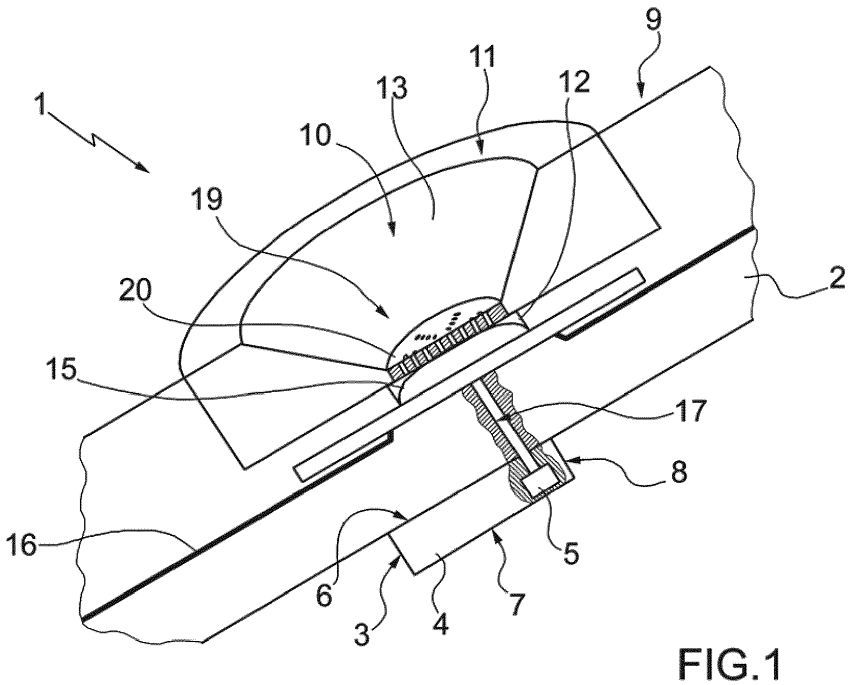

FIG.1

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Description

TECHNICAL FIELD

[0001] The present invention relates to an acoustic device, in particular for applications in the automotive industry.

PRIOR ART

[0002] The use of acoustic devices in the automotive industry comprising a support is known; a microphone device connected to the support and having a sensitive area; an acoustic conduit obtained in a housing connected to the support and designed to convey the sound pressure waves generated by an external acoustic source towards the sensitive area of the microphone device. The acoustic device also comprises a membrane interposed between the microphone device and the acoustic conduit to protect the sensitive area from external agents.

[0003] Electrical and acoustic devices used in the automotive industry must satisfy the standards imposed by the vehicle manufacturers depending on their location (for example, inside the cabin or the engine compartment). For example, devices housed inside the engine compartment must satisfy the standards relating to the so-called ingress protection degree (IP degree). In particular, the value of the ingress protection degree for these applications must be equal to at least 6K7; in other words, the device must be able to resist (meaning of the first term "6K") the ingress of external objects or dust and, at the same time, the device must be able to resist (meaning of the second term "7") thirty minutes of immersion in a liquid at a depth of one meter. The devices housed in the engine compartment must also satisfy the standards imposed by the vehicle manufacturers relating to the so-called specific ingress protection degree for pressurized jets. In particular, the value of the specific ingress protection degree for pressurized jets must be equal to at least IP6K9K; typically elevated pressure values of the jet of water/air incident on the device are reached during operations of washing by means of instruments, which can generate pressurized jets of water/air greater than 5 bar.

[0004] However, the devices of a known type have been found to resist pressure values of the jet of water/air, which is incident on the device, from between 0.1 to 1 bar.

DESCRIPTION OF THE INVENTION

[0005] Therefore, it is an object of the present invention to provide an acoustic device, in particular for applications in the automotive industry, which is without the drawbacks of the state-of-the-art.

[0006] According to the present invention, an acoustic device is provided, in particular for applications in the automotive industry, according to the appended claims.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] The present invention will now be described with reference to the appended drawings illustrating a non-limiting embodiment, wherein:

- figure 1 is a perspective and section view of a first embodiment of an acoustic device produced according to the present invention:
- figure 2 is a section view of the acoustic device in figure 1;
- figure 3 is a section view of a second embodiment of the acoustic device in figure 1;
- figure 4 illustrates a multiplicity of possible variations of a detail of the acoustic device in figure 1;
- figure 5 illustrates a section view of two possible variations of the detail in figure 4; and

PREFERRED EMBODIMENTS OF THE INVENTION

[0008] In figure 1, number 1 globally indicates an integrated device 1 comprising a support 2 bearing a microphone device 3 made up of a body 4, which typically presents the form of a parallelepiped provided with a first and second main face 6, 7 and a lateral surface 8. The body 4 is typically made up of a structural layer of semiconducting material, such as silicon, whereupon conducting/insulating layers can extend, not shown. The microphone device 3 is attached to the support 2 in correspondence with the main face 6 defining an upper surface and is provided with a sensitive area 5. The sensitive area 5 can be formed inside or above the main face 6 of the body 4. For example, the sensitive area 5 can be a membrane delimited at the bottom by a cavity buried in the body, or a suspended membrane or comprise one or more layers extending above the main face 6.

[0009] The support 2 is shaped as a parallelepiped with a larger area or base with respect to the plate 3.

[0010] Then, the device comprises a housing 9 attached above the support 2. In other words, the support 2 is interposed between the housing 9 and the microphone device 3. According to a preferred variation, the housing 9 is made of a metal material. Internally, the housing 9 delimits an acoustic conduit 10 provided with a symmetry axis X. In particular, the acoustic conduit 10 is defined by an upper funnel-shaped portion 11 facing the acoustic source and a lower portion 12. The upper portion 11 is coaxial to the symmetry axis X and is defined by a truncated-cone shaped surface 13 tapered towards the lower portion 12 and it is also coaxial to the symmetry axis X and defined by a cylindrical-shaped surface 14. According to a further variation, the housing 9 is partially defined by a printed body made of a standard material for printing, typically a plastic material, such as resin. According to a preferred variation, the acoustic conduit 10 is made of a metal material. According to a further variation, the acoustic conduit 10 is made of a plastic material.

[0011] The upper funnel-shaped portion 11 is designed to convey and amplify the sound pressure waves coming from external acoustic sources towards the lower portion 12. The diameter of the cylindrical-shaped surface 14 and the angle created between the truncated-cone-shaped surface 13 and the cylindrical-shaped surface 14 are determined so that, with an increase in frequency, the sound waves are progressively amplified, without introducing distortions in the frequency interval typical of the sound field (e.g. between 50Hz-10kHz).

[0012] The device 1 also comprises a membrane 15, which is interposed between the support 2 and the lower portion 12 of the acoustic conduit 10. The membrane 15 is relatively thin and is adapted to protect the sensitive area 5 and it is impermeable to oil, water and dust. The membrane 15 is made of a plastic material.

[0013] Finally, a barrier layer 16 extends in correspondence with the contact area between the housing 9 and the support 2 and electrical connection wires (not illustrated) connect the microphone device 3 to the support 2.

[0014] The microphone device 3 is connected to the outside by means of a through hole 17 made through the support 2 and is in communication with the acoustic conduit 10. In the illustrated embodiment, the through hole 17 vertically overlaps the sensitive area 5 and consequently the acoustic conduit 10, but it could be offset at the side or arranged in any adapted configuration and position.

[0015] The support 2 can be of any known type. According to a preferred variation, the support 2 can be composed of a printed circuit board - pcb - made of organic material or another multi-layer organic substrate (such as, for example a layer of BT - Bismaleimide Triazine) for example of the type LGA ("Land Grid Array") or BGA ("ball grid array"). Alternatively, the support 2 can be composed, in turn, of a support plate made of semiconducting material, typically silicon.

[0016] The barrier layer 16 can be made of a polymeric material with low viscosity or a conducting material, typically a metal material. The barrier layer 16 is relatively thin, for example, it can have a thickness from 20 to 50 μm.

[0017] According to a preferred embodiment, the device 1 also comprises a heating element 18 arranged in proximity to the acoustic conduit 10. According to a preferred variation, the heating element 18 is arranged in proximity to the connection between the upper portion 11 and the lower portion 12 of the acoustic conduit 10. The heating element 18 is driven so that it heats the surface 13 and the surface 14, so that any deposits of particles or oil on such surfaces 13, 14 evaporate without compromising the transfer of the sound waves to the sensitive area 5.

[0018] Finally, the device 1 comprises dissipating means 19 designed to protect the membrane 15 from the collision with possible bodies, which might enter the acoustic conduit 10 and to dissipate the energy of a pressurized water/air jet, which is incident on the device 1. In particular, the dissipating means 19 comprise a perforated metal grid 20 arranged along the acoustic conduit 10. According to a first variation illustrated in figure 2, the grid 20 is arranged in correspondence with one end of the upper portion 11 facing the sound source. The grid 20 presents a round plan shape and fully engages the access opening 10* of the acoustic conduit 10 facing the sound source. According to a second variation illustrated in figure 3, the grid 20 is arranged in proximity to the connection between the upper portion 11 and the lower portion 12 of the acoustic conduit 10. The grid 20 presents a round plan shape and fully engages the lower portion 12.

[0019] It is important to highlight that the heating element 18 is designed to heat the grid 20, too, so that any deposits of particles or oil on the grid 20 evaporate without compromising the transfer of the sound waves to the sensitive area 5.

[0020] According to the illustrations in figures 4 and 5, the grid 20 is provided with a plurality of holes 21, presenting variable dimensions, shape and arrangement based on the frequency of the sound waves to be analyzed. Conveniently, the frequency of the sound waves to be analyzed (and consequently, the dimensioning and arrangement of the holes 21) is determined during an experimental test phase based on the external acoustic sources (and their distance from the acoustic device 1), which generate the pressure waves, which invest the acoustic device 1. Furthermore, the dimensions, shape and arrangement of the holes 21 are advantageously determined based on the resistance to the pressurized water/air jet incident on the acoustic device 1, and on the cost of the grid 20.

[0021] Different geometries are possible, for example:

- a single through hole 21 coaxial to the symmetry axis X with variable dimensions(figures 4e and 4g);
- a plurality of holes 21 with non-uniform dimensions (variable) and uniformly distributed along three circumferences coaxial to the symmetry axis X

[0022] (figure 4a);

- a plurality of holes 21 with non-uniform dimensions (variable) uniformly distributed along the whole grid 20 (figure 4b);
- a plurality of holes 21 with uniform dimensions uniformly distributed along the whole grid 20;
- a plurality of holes with non-uniform dimensions (variable) distributed along three evenly spaced diameters of the grid 20, wherein the holes 20 with a larger width are alternated with the holes with a smaller width, alternatively made in the middle or along the edge of the grid 20 (figures 4f, 4h); and
- a plurality of holes 21 with non-uniform dimensions (variable) distributed along three evenly spaced diameters of the grid 20, wherein the holes 20 with a

larger width are alternatively made in the middle or along the edge of the grid 20 (figures 4f, 4h) ; and

- a plurality of holes 21 with uniform dimensions distributed along three evenly spaced diameters of the grid 20 (figure 4d).

[0023] It is clear that a multiplicity of other hole 21 geometries are possible.

[0024] Furthermore, according to a first embodiment illustrated in figure 5a, the holes 21 are provided with axes 22, parallel to one another and parallel to the symmetry axis X. According to a second embodiment illustrated in figure 5b, the holes 21 are provided with axes 22', parallel to one another and inclined with respect to the symmetry axis X. According to a third embodiment, a group of holes 21 are provided with axes 22, parallel to one another and inclined with respect to the symmetry axis X, and the remaining group of holes 21 are parallel to one another and parallel to the symmetry axis X.

[0025] According to a non-illustrated variation, the microphone device 3 is attached to the support 2 in correspondence with the main face 7 defining a lower surface, interposed between the housing 9 and the support 2. In this case, the microphone device 3 is directly facing the acoustic conduit 10 and it is not necessary to make the through hole 17 through the support 2.

[0026] The device described above presents several advantages. Firstly, it is simple and cheap to manufacture and the grid 20 and the membrane 15 allow the strict standards imposed to be satisfied effectively relating to the ingress protection degree and the specific ingress protection degree for pressurized jets.

Claims

1. An acoustic device (1), in particular for applications in the automotive industry, comprising:

a support (2);
a microphone device (3) connected to the support (2) and having a sensitive area (5);
an acoustic conduit (10) designed to convey the sound pressure waves generated by an external acoustic source towards the sensitive area (5);
wherein the acoustic conduit (10) presents a funnel-shaped portion (11) to convey and amplify the sound pressure waves coming from the external acoustic source towards a cylindrical portion (12) in communication with the sensitive area (5); and
a membrane (15) interposed between the microphone device (3) and the cylindrical portion (12) of the acoustic conduit (10) to protect the sensitive area (5) from external agents;
the device is **characterized in that** it comprises a grid (20) made of a metal material and arranged along the acoustic conduit (10) to protect the membrane (15) from the collision with possible bodies, which might enter the acoustic conduit (10) and to dissipate the energy of a pressurized fluid jet, which is incident on the device (1).

2. The device according to claim 1 comprising a heating device (18) arranged in proximity to the acoustic conduit (10) to heat a surface (13, 14) of the acoustic conduit (10) and the grid (20).

3. The device according to claim 1 or 2, wherein the grid (20) is arranged in correspondence with the connection between the funnel-shaped portion (11) and the cylindrical-shaped portion (12) of the acoustic conduit (10).

4. The device according to the claim 1 or 2, wherein the grid (20) is arranged in correspondence with the end of the funnel-shaped portion (11) facing the external acoustic source.

5. The device according to anyone of the preceding claims, wherein a number of holes (21) greater than or equal to one are made in the grid (20).

6. The device according to claim 5, wherein the acoustic conduit (10) presents a symmetry axis (X) and the holes (21) are provided with respective axes (22') parallel to one another and inclined with respect to the symmetry axis (X).

7. The device according to claim 5, wherein the acoustic conduit (10) presents a symmetry axis (X) and the holes (21) are provided with respective axes (22) parallel to one another and parallel to the symmetry axis (X).

8. The device according to anyone of the claims from 5 to 7, wherein the holes (21) present a width and an arrangement, which can vary based on the frequency of the sound waves to be analyzed generated by the sound sources, which invest the acoustic device (1).

9. The device according to anyone of the preceding claims, wherein the support (2) is interposed between the membrane (15) and the microphone device (3); and wherein the microphone device (3) is connected to the outside by means of a through hole (17) made through the support (2) in communication with the acoustic conduit (10).

10. The device according to anyone of the claims from 1 to 8, wherein the microphone device (3) is interposed between the membrane (15) and the support (2).

11. The device according to anyone of the preceding claims, wherein the acoustic conduit (10) is made of a metal material.

12. The device according to anyone of the claims from 1 to 10, wherein the acoustic conduit (10) is made of a plastic material.

13. The device according to anyone of the preceding claims, wherein the acoustic conduit (10) is obtained in a housing (9) made of a metal material.

14. The device according to anyone of the claim from 1 to 12, wherein the acoustic conduit (10) is obtained in a housing (9) made of a plastic material.

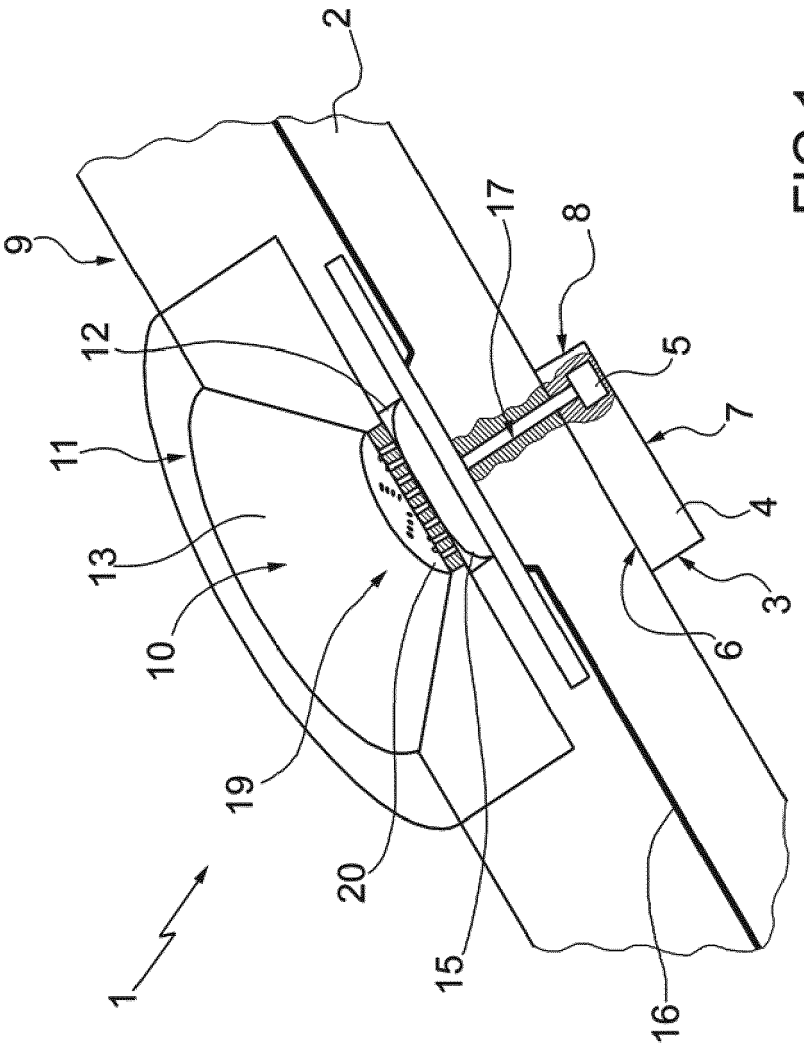

FIG.1

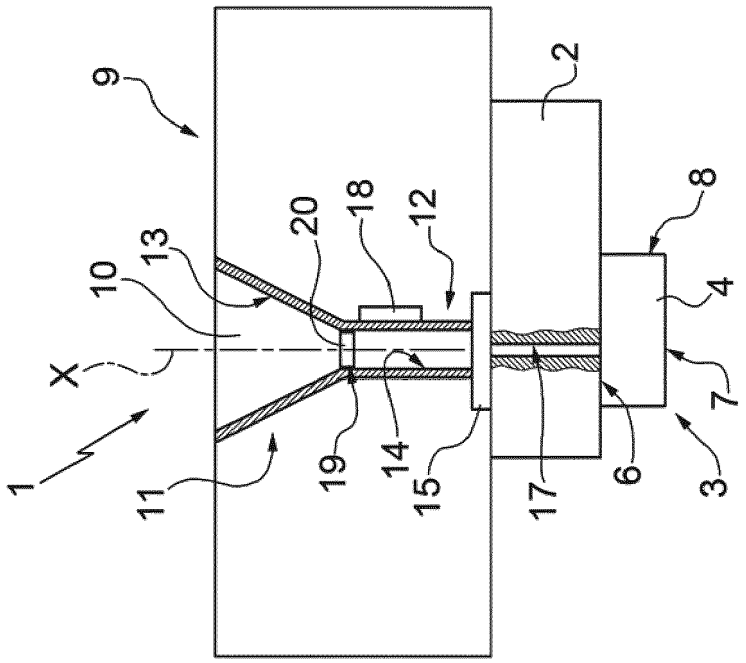
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FIG.3

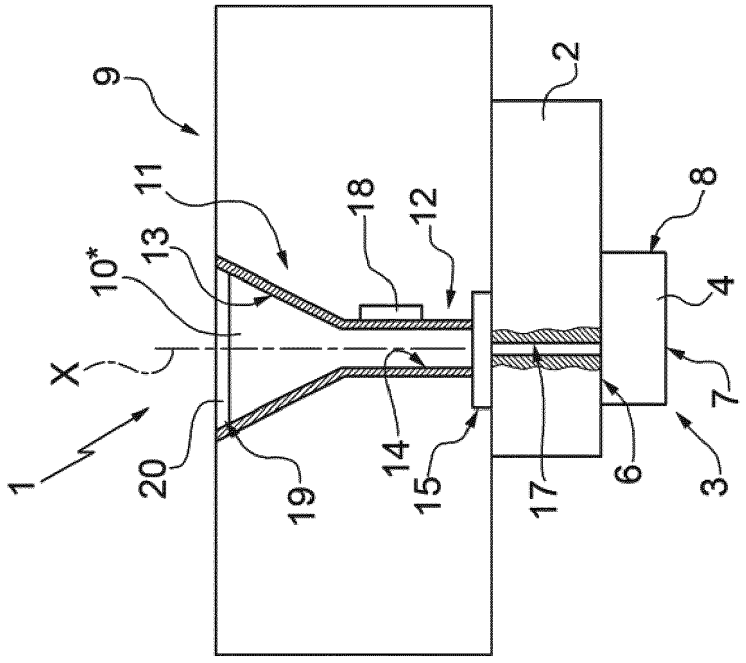
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FIG.2

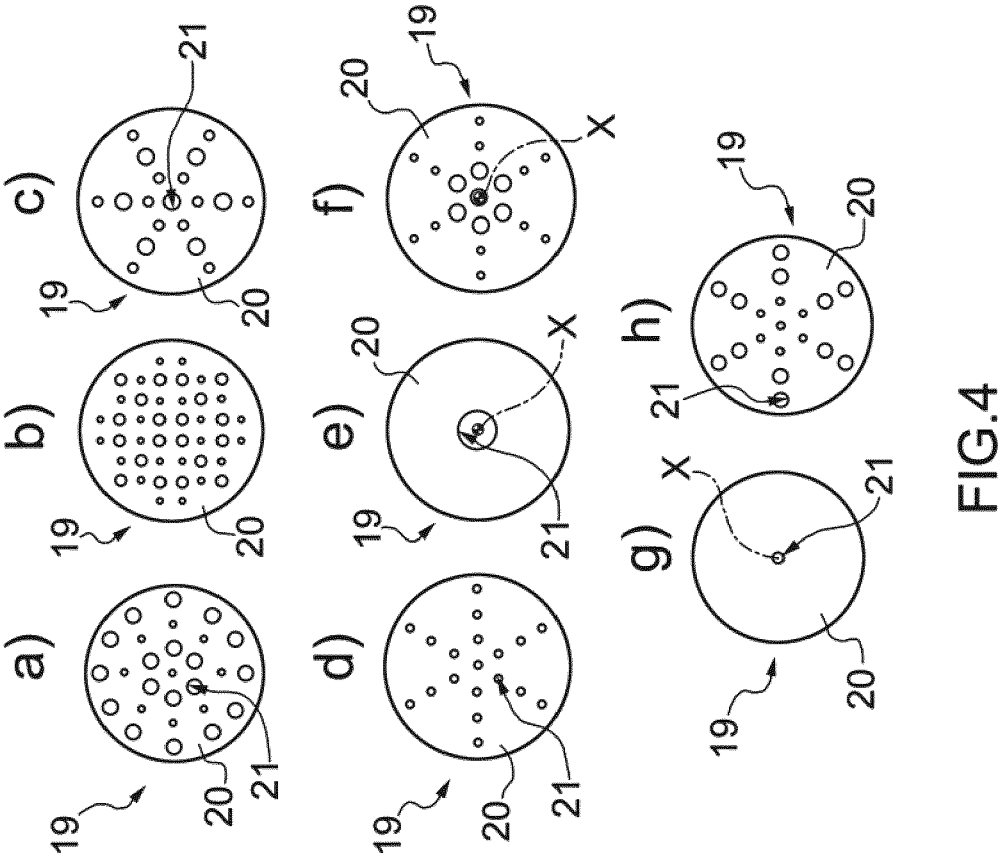

FIG.4

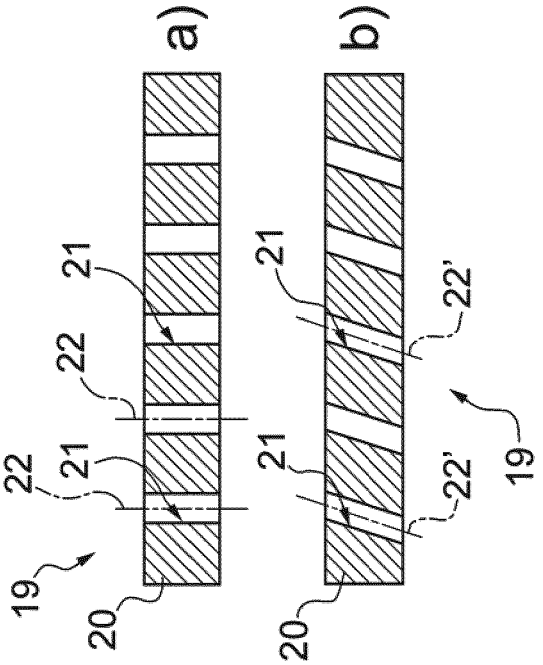

FIG.5

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EUROPEAN SEARCH REPORT

Application Number
EP 17 21 0764

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	EP 3 059 125 A1 (PANASONIC IP MAN CO LTD [JP]) 24 August 2016 (2016-08-24)	8	INV. H04R1/08
A	* figures 1,2,4-6 * * figures 13-17,20 * * paragraph [0080] - paragraph [0088] * * paragraph [0133] - paragraph [0140] *	1-7,9-14	H04R1/30
X	US 2014/198932 A1 (PARKINS JOHN W [US]) 17 July 2014 (2014-07-17)	8	
A	* figures 1-10 *	1-7,9-14	
X	FR 2 547 967 A1 (HORLOGERIE PHOTOGRAPH FSE [FR]) 28 December 1984 (1984-12-28)	8	
A	* figures 1-7 * * page 1, line 34 - page 2, line 6 * * page 3, line 1 - line 9 *	1-7,9-14	

TECHNICAL FIELDS SEARCHED (IPC)

H04R

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	3 May 2018	Moscu, Viorel

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 17 21 0764

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03-05-2018

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