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(54) **DEVICE FOR REDUCING SOUND**

(57) The invention relates to a device for reducing sound, particularly sound of traffic travelling over a road or track, which device comprises a body with a main surface, wherein one or more grooves are arranged in the main surface, wherein each groove extends in a first direction and is bounded by a first groove edge and a second groove edge, wherein the two groove edges extend parallel to the first direction and lie in the main surface of the body
wherein each groove comprises a first groove wall hanging downward from the first groove edge, which first groove wall forms an angle of between 60° and 100°, preferably 90°, with the main surface.
wherein each groove further comprises a second groove wall rising from the lower side of the first groove wall to the second groove edge, wherein the second groove wall is flat or concave as seen in the first direction
and wherein the ratio of the distance between the first groove edge and the second groove edge of a groove to the depth of the relevant groove lies between 1.0 and 3.0.

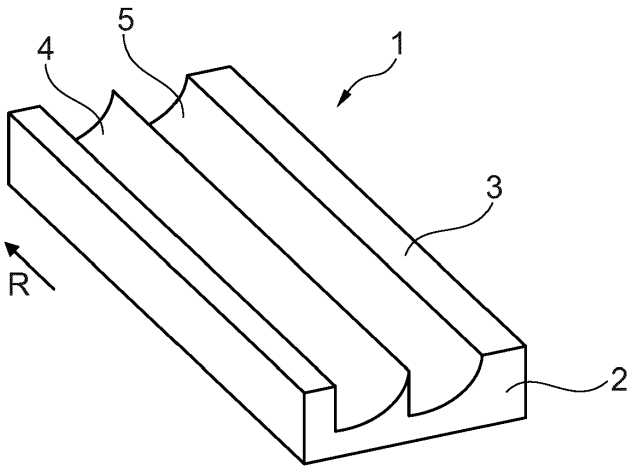

Fig. 1

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Description

[0001] The invention relates to a device for reducing sound, particularly sound of traffic travelling over a road or track, which device comprises a body with a main surface, wherein one or more grooves are arranged in the main surface, wherein each groove extends in a first direction and is bounded by a first groove edge and a second groove edge, wherein the two groove edges extend parallel to the first direction and lie in the main surface of the body

wherein each groove comprises a first groove wall hanging downward from the first groove edge, which first groove wall forms an angle of between 60° and 100°, preferably 90°, with the main surface.

[0002] Such a device is known from EP 3019662. In this publication the grooves are designed such that they function as resonators for different sound frequencies. The resonators diffract the sound moving over the device upward, so that an area where the sound pressure is reduced is created behind the device.

[0003] In order to have a resonance be generated in the grooves the depth of the groove can equal up to several times the width of the groove. The depth of the groove is here a quarter of the wavelength of the desired resonance frequency. For frequencies between 700 Hz and 1200 Hz, which are characteristic for sound of traffic travelling over a road, the depth of a groove varies between 0.07 m and 0.12 m, at a width of for instance 0.03 m. In addition, a separate groove must be formed for each desired resonance frequency, this making the device complex.

[0004] It has been found that making a body with grooves with such dimensions is difficult when requirements such as strength, ability to withstand vehicles driving thereover and the like must be taken into consideration. A considerable amount of material is moreover necessary for each device, which in turn is disadvantageous in transporting and placing of the devices.

[0005] In addition, the resonance in the grooves takes time to get underway before the sound-reducing effect is obtained. In the case of a continuous sound production this will only be noticeable in the initial stage, but when the intensity and/or frequencies of the sound production vary, the average sound reduction of such a known device can be lower than in the case of a continuous sound production.

[0006] It is therefore an object of the invention to reduce or even obviate the above stated drawbacks.

[0007] This object is achieved according to the invention with a device according to the preamble, which is characterized in that each groove further comprises a second groove wall rising from the lower side of the first groove wall to the second groove edge, wherein the second groove wall is flat or concave as seen in the first direction

and wherein the ratio of the distance between the first groove edge and the second groove edge of a groove to the depth of the relevant groove lies between 1.0 and 3.0.

[0008] The device according to the invention diffracts the sound moving over the device upward in a different manner than in the prior art. Sound which has moved over the first groove edge of the groove will propagate in the groove and reflect against the rising second groove wall. The direction of the sound wave will hereby change and exit the groove more or less perpendicularly of the main surface. The sound waves which have changed direction will here act on the sound waves running parallel to the main surface of the device, and thereby push the sound waves away from the main surface of the device, whereby an area with reduced sound pressure is created behind the device.

[0009] In order to provide sufficient space for the reflection of the sound waves on the second groove wall the width of the groove, i.e. the distance between the first and second groove edge, must at minimum equal the depth of the groove. The depth of the groove is determined by the distance between the main surface and the lowest point in the groove, at the position where the second groove edge connects to the first groove edge.

[0010] Finally, the ratio of the distance between the first groove edge and the second groove edge of a groove to the depth of the relevant groove must not be greater than 3 in order to prevent the rising second groove wall from being too flat, this causing the reflected sound waves to move along with the sound moving over the main surface too much and to no longer have a diffracting effect.

[0011] In a preferred embodiment of the device according to the invention the depth of the groove lies between 0.04 m and 1.0 m, preferably 0.04 m and 0.25 m. It has been found that when the depth is a quarter of the wavelength of a frequency, the sound-reducing effect occurs starting at this frequency and for the frequencies thereabove. In normal circumstances, wherein the speed of sound lies at 331 m/s, a depth of the groove of between 0.04 m and 0.25 m provides for a sound reduction of frequencies between 331 Hz and 2068 Hz.

[0012] In another preferred embodiment of the device according to the invention the second groove wall is formed, as seen in the first direction, according to an Nth degree polynomial, wherein N is a minimum of 1.0 and wherein N is preferably 2.

[0013] The most optimal form of the second groove wall is, as seen in the first direction, so in cross-section, a parabolic form. This ensures that the path lengths for the sound waves from the first groove edge via the second groove edge to the main surface are equal. The reflected sound waves hereby provide for a maximum deflection of the sound moving over the main surface. Nevertheless, a second groove wall formed according to an Nth degree polynomial, wherein N lies between 1.0 and 3.0, still provides for diffraction of the sound and thereby for a sound reduction.

[0014] In yet another embodiment of the device according to the invention a grating extending at least from

the first groove edge to the second groove edge is arranged in the one or more grooves.

[0015] When the device is arranged alongside a road, the main surface must be suitable for a wheel of a vehicle driving thereover. Due to the width of the grooves, which can be up to 0.5 m, it must be prevented that a vehicle ends up with a wheel in the groove. This is prevented by arranging a grating, while the sound waves can still enter the grooves.

[0016] A preferred embodiment of the grating can be formed by partitions placed transversely in the grooves. These partitions can be formed integrally with the groove wall and are preferably provided with a drainage opening so that water can flow out of the grooves.

[0017] In yet another embodiment of the device according to the invention at least the second groove wall of each groove is formed by a photovoltaic layer.

[0018] Since the device is highly suitable for arranging along great lengths of road, the surface provides sufficient space for forming solar panels therefrom.

[0019] The invention further relates to a combination of a road and a device according to the invention, wherein the device is arranged adjacently of the road and with the first direction parallel to the longitudinal direction of the road.

[0020] An embodiment of the combination according to the invention further comprises a wall, such as a sound barrier, arranged adjacently of and parallel to the road, wherein the device is arranged on the upper edge of the wall.

[0021] The device is further highly suitable for arranging on the upper edge of a wall or sound barrier. Hereby, either the sound reduction of the wall can be further improved or the height of the wall can be reduced, while the desired sound reduction is preserved.

[0022] In a preferred embodiment of the combination according to the invention the main surface of the body forms an angle of between 0° and 90° with the road.

[0023] When the main surface is kept parallel to the road while the device is arranged on top of a wall, a large part of the grooves will lie outside the path of the skimming sound propagating over the wall and the device. By tilting the main surface, the main surface can still be oriented such that the sound of the road moves over the whole main surface and a maximum reduction is thus provided.

[0024] These and other features of the invention are further elucidated with reference to the accompanying drawings.

Figure 1 shows a perspective view of an embodiment of a device according to the invention.

Figure 2 shows a cross-sectional view of a groove of the device according to figure 1.

Figure 3 shows a schematic representation of the reflection of a sound wave in the groove according to figure 2.

Figure 4 shows a perspective view of a first embodiment of a combination according to the invention.

Figure 5 shows a schematic cross-section of a second embodiment of a combination according to the invention.

Figure 6 shows a heat map of the sound pressure without a device according to the invention.

Figure 7 shows a heat map of the sound pressure with a device according to the invention.

Figure 8 shows a graph of the sound pressure at a point according to figures 6 and 7.

[0025] Figure 1 shows a perspective view of a device 1 according to the invention. The device 1 has a body 2 with a main surface 3, in which are arranged two grooves 4, 5 extending in a first direction R.

[0026] Figure 2 shows a cross-sectional view of the groove 4, 5. Each groove 4, 5 is bounded in the main surface 3 by a first groove edge 6 and a second groove edge 7.

[0027] A first groove wall 8 hangs downward from the first groove edge 6. This first groove wall 8 forms an angle α with the main surface 3. This angle α lies between 60° and 100°, preferably 90°.

[0028] A second groove wall 10, which rises toward the second groove edge 7, connects to the lower edge 9 of the first groove wall 8. In cross-section the form of the second groove wall 10 is equal to a part of an Nth degree polynomial, wherein N is a minimum of 1.0 and wherein N is preferably 2.

[0029] The ratio of the width b of groove 4, 5 to the depth d of groove 4, 5 lies between 1.0 and 3.0, and is preferably 2.0.

[0030] Figure 3 shows the device 1 in cross-section, wherein sound G moves over main surface 3. At the first groove edge 6 a part of the sound G will enter groove 4 and reflect on second groove wall 10. This reflected sound G_r will push the sound G upward, whereby a reduction in sound pressure will be obtained behind groove 4.

[0031] Figure 4 shows a first embodiment 20 of a combination according to the invention. In this combination a row of devices 1 according to the foregoing figures is arranged along a traffic road 21, whereby the sound along the road 21 is reduced.

[0032] Figure 5 shows a second embodiment 30 of a combination according to the invention in cross-section. A sound barrier 32 is here placed alongside a traffic road 31. An embodiment of the device 33 according to the invention is placed on the upper edge of sound barrier 32. Because device 33 is arranged at a raised position, the main surface 34 of device 33 is placed at an angle β so that the grooves 35, 36 can work optimally.

[0033] Figure 6 shows a heat map of the sound pressure caused by a sound source G. Figure 7 shows a heat map of the sound pressure caused by this same sound source G, but wherein a device 40 with four grooves according to the invention is arranged.

[0034] On the basis of the heat map it will be apparent that in point 41 the sound pressure is higher without de-

vice 40 than when device 40 is placed.

[0035] Figure 8 shows a graph of the sound pressure SPL in point 41, depending on the frequency. It can be clearly seen that when device 40 is applied from a starting frequency (in this case about 400 Hz) a considerable reduction in sound pressure is obtained over the further frequency range.

Claims

1. Device for reducing sound, particularly sound of traffic travelling over a road or track, which device comprises a body with a main surface, wherein one or more grooves are arranged in the main surface, wherein each groove extends in a first direction and is bounded by a first groove edge and a second groove edge, wherein the two groove edges extend parallel to the first direction and lie in the main surface of the body

   wherein each groove comprises a first groove wall hanging downward from the first groove edge, which first groove wall forms an angle of between 60° and 100°, preferably 90°, with the main surface.
   characterized in that
   each groove further comprises a second groove wall rising from the lower side of the first groove wall to the second groove edge, wherein the second groove wall is flat or concave as seen in the first direction
   and wherein the ratio of the distance between the first groove edge and the second groove edge of a groove to the depth of the relevant groove lies between 1.0 and 3.0.

2. Device according to claim 1, wherein the depth of the groove lies between 0.04 m and 1.0 m, preferably 0.04 m and 0.25 m.

3. Device according to claim 1 or 2, wherein the second groove wall is formed, as seen in the first direction, according to an Nth degree polynomial, wherein N is a minimum of 1.0 and wherein N is preferably 2.

4. Device according to any one of the foregoing claims, wherein a grating extending at least from the first groove edge to the second groove edge is arranged in the one or more grooves.

5. Device according to any one of the foregoing claims, wherein at least the second groove wall of each groove is formed by a photovoltaic layer.

6. Combination of a road and a device according to any one of the foregoing claims, wherein the device is arranged adjacently of the road and with the first direction parallel to the longitudinal direction of the road.

7. Combination according to claim 6, further comprising a wall, such as a sound barrier, arranged adjacently of and parallel to the road, wherein the device is arranged on the upper edge of the wall.

8. Combination according to claim 7, wherein the main surface of the body forms an angle of between 0° and 90° with the road.

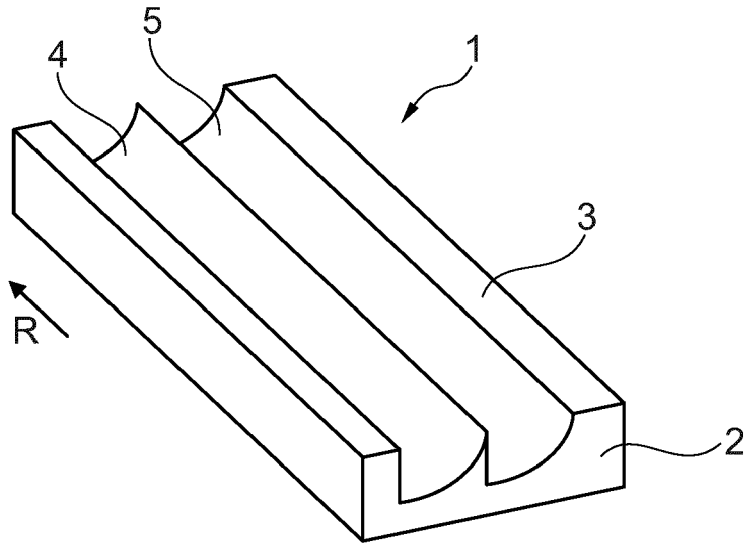

Fig. 1

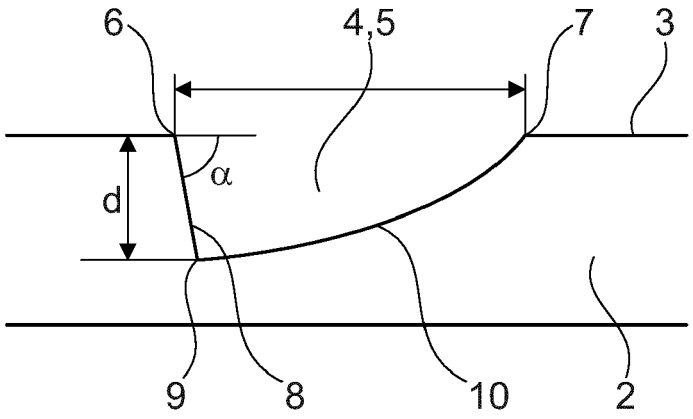

Fig. 2

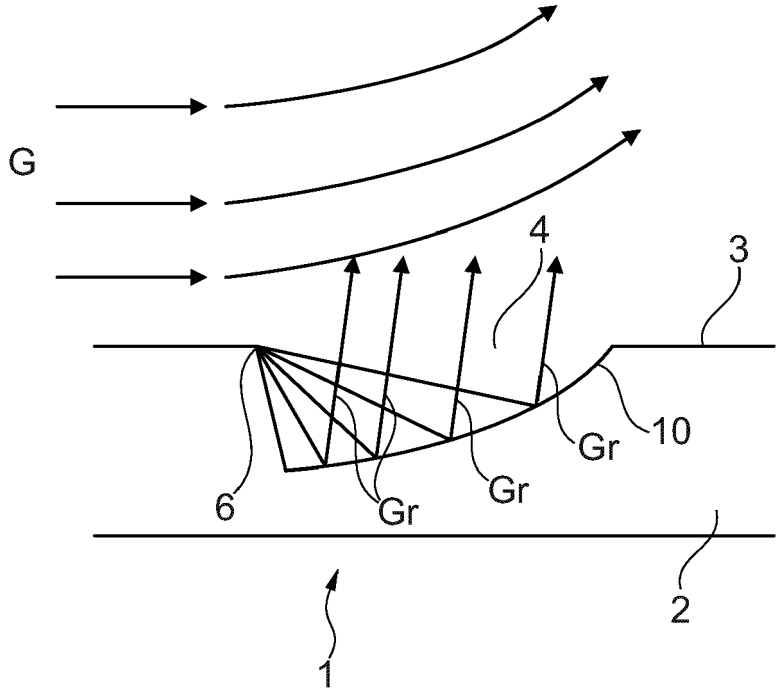

Fig. 3

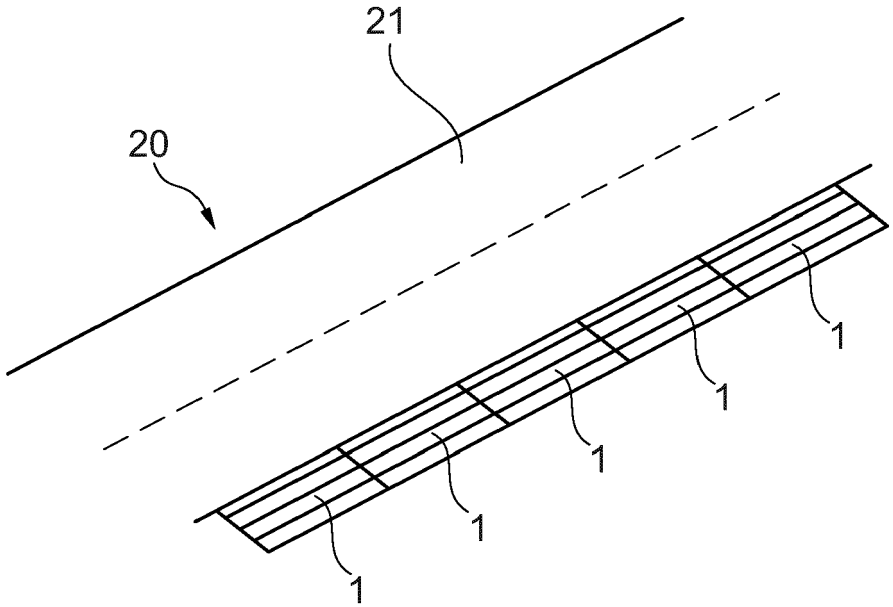

Fig. 4

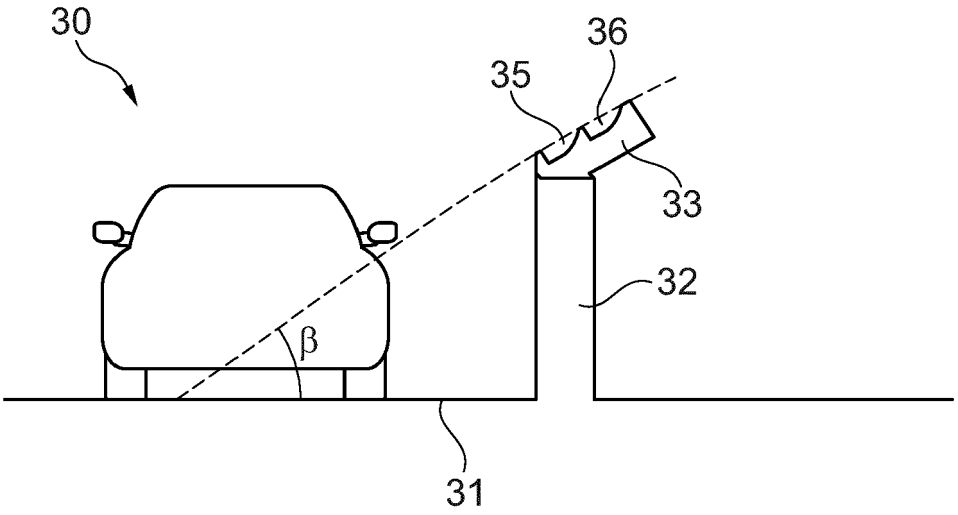

Fig. 5

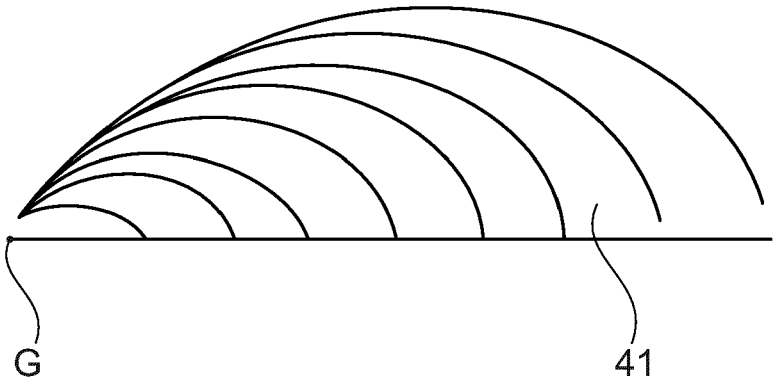

Fig. 6

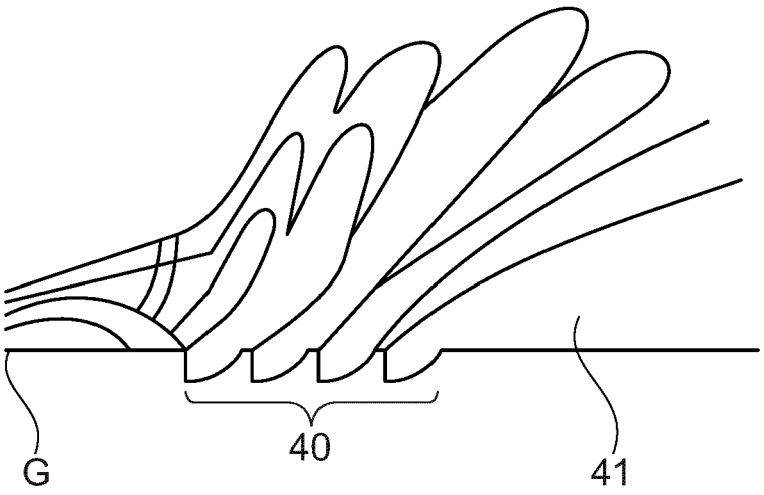

Fig. 7

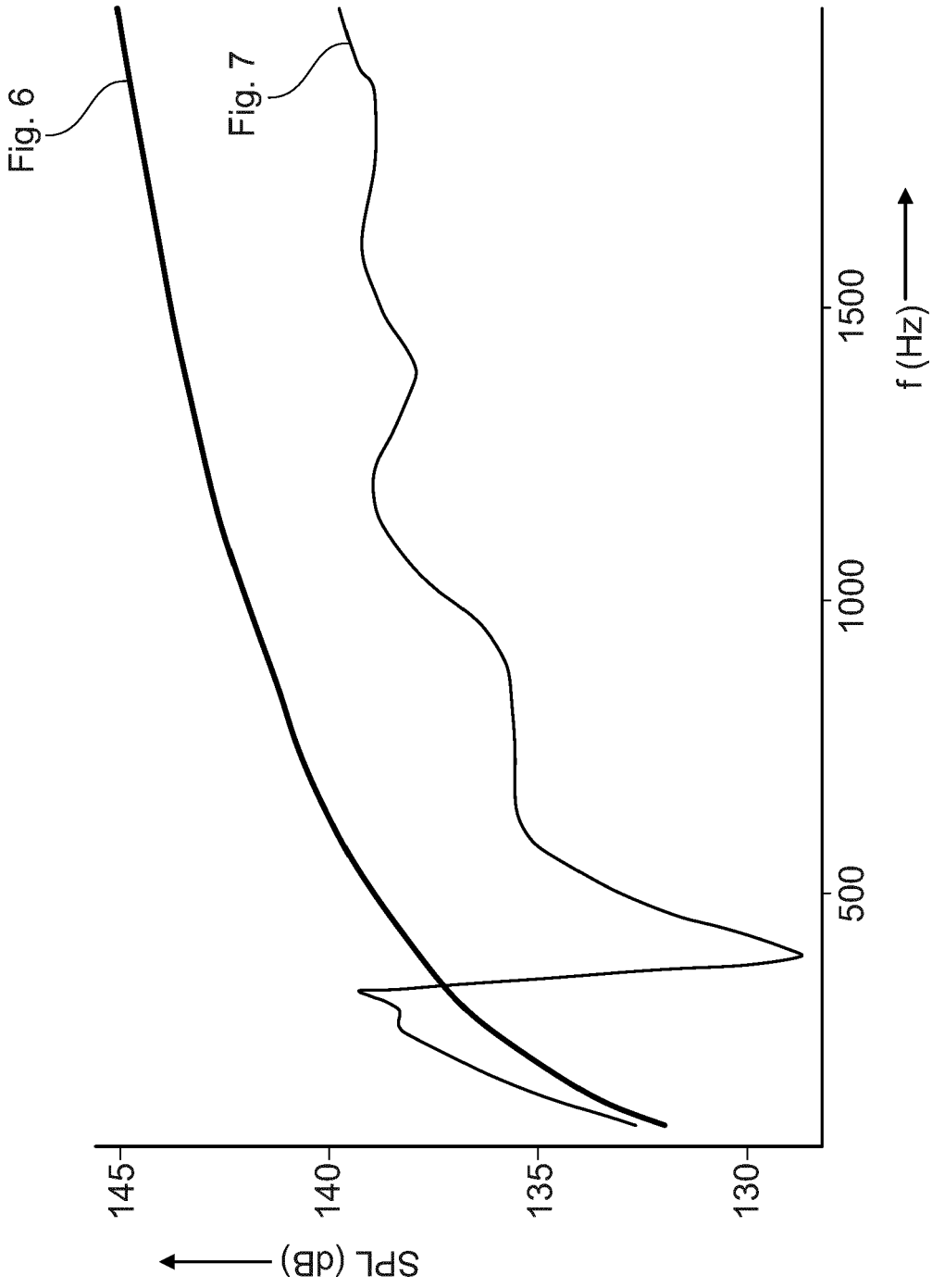

Fig. 8

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Application Number
EP 22 18 2850

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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	17 November 2022	Flores Hokkanen, P

CATEGORY OF CITED DOCUMENTS

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