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(54) Title: IN-CAR LOUDSPEAKER ARRAY POSITIONING

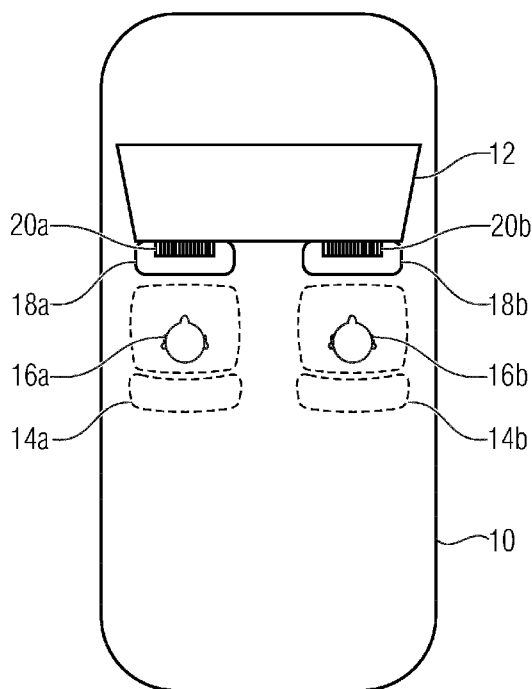


FIG 1A

(57) Abstract: Spatial audio transducer system comprises a sun visor (18a, 18b) of a vehicle (10) and a spatial audio transducer array (20a, 20b). The array (20a, 20b) comprises at least three individual audio transducers, wherein the spatial audio transducer array (20a, 20b) is integrated into the sun visor (18a, 18b) or into a headlining of the vehicle (10) such that same overlaps at least partially with the sun visor (18a, 18b) at a closed position of the sun visor (18a, 18b).



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In-Car Loudspeaker Array Positioning

Description

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Embodiments of the present invention refer to a spatial audio transducer system and a positioning thereof, especially a positioning inside a vehicle.

10 According to common approaches the loudspeakers in a vehicle are typically positioned in the doors, the dashboard or the back shelf. A further very common position is the A pillar, especially for tweeters. However, the positions in the front of a passenger vehicle are limited. These limitations appear especially in the case if loudspeaker arrays for spatial
15 audio reproduction, like spotforming, beamforming, wavefield synthesis reproduction or higher-order ambisonics techniques, should be placed. Due to these placement constraints, these techniques are not broadly used in automotive scenarios. These limitations result in a non-present or non-optional 3D/surround reproduction. This limitation applies to multizone reproduction, too. Therefore, there is the need for an improved approach.

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Therefore, it is the objective of the present invention to provide a concept enabling improved surround or multizone reproduction for a sound system of a vehicle.

This objective is solved by the independent claims.

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An embodiment of the invention provides a spatial audio transducer system. The system comprises a sun visor of a vehicle and a spatial audio transducer array. The array comprises at least three individual audio transducers, wherein the spatial audio transducer array is integrated into the sun visor (e.g. at a main surface of the sun visor facing to the
30 occupants) or into a headlining of the vehicle such that same overlaps at least partially with the sun visor at a closed position of the sun visor.

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Teachings of the invention disclosed herein are based on the knowledge that the area around the sun visor is optimal for positioning spatial audio transducer arrays. This positioning is superior to others due to proximity to the occupants' heads and the location in front of the occupants at the same time. Therefore, it is a basic idea to use a

loudspeaker array for audio reproduction in a vehicle, which is located at the position or near to a sun visor. Here, the sun visor provides sufficient space to capture a loudspeaker array effectively for directional audio reproduction. The used arrays combine two advantages, namely that they are capable of reproducing surround sound or multizone sound and that such arrays are flat enough to be arranged within a sun visor or within a headlining in the area of the sun visor.

Starting from this, there are different concepts to arrange the spatial audio transducer array. According to a first enhanced embodiment, the array may be integrated in the sun visor, wherein the sun visor comprises an opening at an edge, which is opposite to the edge of the joint of the sun visor.

According to a further embodiment, the spatial audio transducer array may be integrated into the headlining behind or at least overlapping the sun visor. In this case, the sun visor comprises an acoustically transparent material.

According to further embodiments the spatial audio transducer array is integrated into the joint of the sun visor or integrated into the headlining at the joint of the sun visor.

According to a further embodiment, the spatial audio transducer array is arranged at a first main surface of the sun visor facing to the passenger. Here, there are two variants: according to a first variant the sun visor is coupled via one or more rails to the headlining, such that the relative position between the main surface and the passenger does not significantly change in case the sun visor is moved from the closed position to the open position. According to a second variant, the sun visor may comprise a second spatial audio transducer array arranged at a second surface facing to the headlining. Here, the first or second array is enabled and disabled dependent on the position of the sun visor (open position or closed position).

For all of the above embodiments it may be advantageous that the sun visor may be coupled to a sun visor sensor which is configured to detect a position of the sun visor. Dependent on the detected position of the sun visor an optional sound processor may process the audio signals for the audio transducers. For example, this processor may perform the switching between the first and the second array or may process the audio signals in order to adapt a frequency response of the audio transducers. For example, the sound processor may comprise one or more filters, wherein the filter coefficients of the

filters are adapted dependent on the detected position of the sun visor. In this case, the adaption of the filter coefficients may be dependent on a detected angle of the sun visor. Thus, the sun visor sensor may be an angle sensor.

- 5 All of the above approaches solve the problem that the indispensable sun visor constitutes an obstacle in the placement of loudspeaker at some positions.

All of the above embodiments have the advantage that in all above embodiments, the array comprises at least three transducers, which are preferably, but not necessarily,
10 loudspeakers. According to further embodiments, the transducers or at least one transducer may be a microphone.

The arrays may, according to embodiments, or according to further embodiments, be two-dimensional arrays, wherein the single transducers of the arrays are typically controlled
15 independently.

Below, embodiments of the invention will subsequently be discussed referring to the drawings, wherein:

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Fig. 1a shows a schematic illustration of the elected location for the array inside the vehicle;

Fig. 1b shows a schematic block diagram illustrating the usage of multiple
25 loudspeakers as arrays (single input signal);

Fig. 1c shows a schematic block diagram illustrating the usage of multiple loudspeakers as an array (with multiple input signals);

30 Figs. 2a-2c illustrate a basic embodiment of a spatial audio transducer system;

Figs. 3a-3c illustrate an enhanced embodiment of a spatial audio transducer system according to a first variant;

35 Figs. 4a-4c illustrate an enhanced embodiment of a spatial audio transducer system according to a second variant;

Figs. 5a-5c illustrate an enhanced embodiment of a spatial audio transducer system according to a third variant;

5 Figs. 6a-6c illustrate an enhanced embodiment of a spatial audio transducer system according to a fourth variant;

Figs. 7a-7c illustrate an enhanced embodiment of a spatial audio transducer system according to a fifth variant; and

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Figs. 8a-8c illustrate an enhanced embodiment of a spatial audio transducer system according to a sixth variant.

15 Below, embodiments of the present invention will be discussed in detail referring to the figures. Here, the same reference numerals are provided to elements or structures having an identical or similar function. Therefore, the description thereof is mutually applicable or interchangeable.

20 Fig. 1a shows a schematic top view of a vehicle 10 comprising a windshield 12 and two seats 14a and 14b for the two passengers 16a and 16b. As can be seen, adjacent to the windshield 12 at the headlining of the vehicle 10 two sun visors 18a and 18b are attached to the headlining. The position of the sun visors 18a and 18b, which have the property to avoid dazzling of the passengers 16a and 16b caused by the sun, is typically the edge
25 formed by the windshield 12 and the roof of the vehicle 10. Commonly, sun visors 18a and 18b are coupled to the headlining using a rotatable joint so that the sun visor may be moved from a closed position (in parallel to the headlining) to an open position (in parallel to the windshield 12) or vice versa.

30 As mentioned above, the sun visors 18a and 18b are beneficial positions for the loudspeaker arrays 20a and 20b, wherein the loudspeaker array 20a and the purpose to provide a sound field for the passenger 16a and wherein the loudspeaker array 20b has a purpose to provide a sound field for the passenger 16b. From the geometric perspective, the space adjacent to the top end of the windshield 12 is attractive for the placement of
35 transducer arrays 20a and 20b. This is because it is in front of the occupants, it is nearby the occupants' heads and provides a considerable width to place multiple loudspeakers

20a/20b. As illustrated, the loudspeaker arrays 20a and 20b can be implemented either for both or for a single passenger seat 14a/14b.

Due to the positioning of the loudspeaker arrays 20a and 20b, it is possible to implement beamformers that radiate sound predominantly to a desired direction so that multizone reproduction is enabled. A typical usage for such loudspeaker arrays 20a and 20b is spatial audio reproduction, like beamforming / spotforming or wavefield synthesis reproduction and higher-order ambisonics reproduction techniques. Typically loudspeaker arrays are used for such techniques. The basics for the loudspeaker arrays will be discussed with respect to Figs. 1a and 1b.

In the following, it is important to distinguish the term loudspeaker array from the use of individual loudspeaker: a set of multiple loudspeakers is used as a loudspeaker array, whenever the reproduction system feeds one input signal to multiple loudspeakers that are primarily excited in the same frequency range. An exemplary block diagram of such a setup is shown by Fig. 1b, where the blocks 24a and 24b (denoted with filter) can describe linear or nonlinear, signal-dependent, signal-independent, time-varying, or time-invariant filters that typically differ from each loudspeaker channel (reference numeral 44a and 44b).

The implementation of such loudspeaker arrays into or next to the sun visor is not as simple as it looks. The background thereof is that nothing must obstruct the view through the windshield. Further, while placement is already a challenge for single loudspeakers, this problem intensifies when multiple loudspeakers should be placed near each other, given that a loudspeaker array should have a considerable aperture. Below, approaches enabling to overcome these limitations will be discussed with respect to Figs. 2 to 8.

Figs. 2a to 2c show three views of a spatial audio transducer system 100, wherein the view of Fig. 2a is the view of a passenger to the system 100 in case the sun visor is open and wherein Fig. 2b is the same passenger's view in case the sun visor is closed. Fig. 2c shows a side view of the system 100, wherein the closed position is illustrated by broken lines and the open position illustrated by unbroken lines. It should be noted that the embodiment of Figs. 2a to 2c comprises two/three alternative variants of positioning the array, namely positioning the array within the sun visor according to a first variant and positioning the array within or at the headlining according to a second variant.

The spatial audio transducer system 100 comprises the sun visor 18 and the spatial audio transducer array 20 comprising a plurality or at least three individual loudspeakers 20a to 20g. In this embodiment, the sun visor is attached to the headlining 24 via a joint 26 arranged at an edge of the headlining 24 or the roof and the windshield 28. Due to the joint 26 the sun visor 18 may have a closed position (cf. Fig. 2b and sun visor illustrated by broken lines within Fig. 2c) in which the sun visor 18 is in contact or in parallel to the headlining 24. Furthermore, the sun visor 18 may be in an open position (cf. Fig. 2a and sun visor 18 of Fig. 2c) in which the sun visor 18 is substantially in parallel to the windshield 28.

The loudspeaker array 20 is integrated into the sun visor 18 or its main surface. In this case the array 20 may be, for example, a line array. A sound opening of the array 20 may be arranged at one or both of the two main surfaces of the sun visor 18. As can be seen, the emission direction of the loudspeaker array 20 depends on the position of the sun visor 18. Therefore, it may be advantageous to use sound opening to both sides or bidirectional loudspeakers 20a to 20g, like dipole loudspeakers. Due to this, a proper spatial audio reproduction (multizone reproduction, e.g. realized by spotforming) for the passenger may be provided independent from the position of the sun visor.

Optionally, the audio signal for the plurality of loudspeakers 20a to 20g may be adapted dependent on the position of the sun visor 18, such that a sound direction is adjusted. Therefore, the spatial audio transducer system 100 may comprise an optional sensor 30 for detecting the position of the sun visor 18. The sensor 30 may be configured to detect whether the sun visor 18 is in the open or the closed position. Furthermore, the sensor 30 may be configured to detect an angle of the sun visor 18 against the headlining 24. Dependent on the detected position of the sun visor 18, the audio signal for the array 20 (e.g. the frequency range or the phase) may be adapted gradually or continuously.

According to a further variant of the spatial audio transducer system 100, the array 20 may be integrated or attached to the headlining 24. This variant is marked by a star within Fig. 2c. As can be seen, the array 20* is arranged at the headlining overlapping the sun visor in a closed position. Here, it may be beneficial to adapt the audio signal dependent on the position of the sun visor 18.

According to a third variant, a combination of the first and the second variant may be possible. Thus, the array 20 emitting sound via the main surface in the closed position

may be activated when a sun visor is in a closed position, wherein the array 20* may be activated when the sun visor is in the open position. In this case, the array 20* may also be positioned directly in front of the closed sun visor 18. This placement would imply the weakest influence of the sun visor on the radiation properties.

5

In all embodiments of variants, it is a technical problem to be solved that the sun visor 18 represents an obstacle, which must not be restricted in its positioning due to loudspeaker positioning. On the other hand, the sun visor can influence the radiation properties of the loudspeaker beneficially. This effect has either to be minimized or the filters implementing array processing approaches have to be adapted accordingly. For this adaption, the array 10 20 or 20* may be coupled to the processor for processing the audio signal. This processing may comprise tuning of an equalizer or switching on or off the equalizer or other means, e.g. for adapting the frequency range of the seven loudspeakers 20a to 20g. The processor may be implemented as a CPU or as a filter, like explained with respect to 15 Fig. 1b or 1c.

As explained above, it may be beneficial to perform the processing dependent on the position of the sun visor or dependent on the angle of the sun visor 18. I.e., dependent on the position of the sun visor parameters used for the deforming may be adapted, since the 20 relative position between the passenger and the transducer array 20 varies along the movement of the sun visor 18.

With respect to the transducers 20a to 20g, it should be noted that above embodiments or variants are not related to a specific transducer concept can be realized with any 25 transducer concept, like electrodynamic actuators, electrostatic actuators, air motion transformers, or others. Even though in above embodiments or variants, the concept of the invention is explained in the context of audio transducers in the sense of loudspeakers, it should be noted that the invention is not limited to transducers configured to emit a sound, but also may be realized with microphone arrays or a combination of 30 loudspeakers and microphone arrays.

Figs. 3a to 3c show a further embodiment using the above teachings. Here, Fig. 3a shows the passenger's view of the spatial audio transducer system 100' in the open position, wherein Fig. 3b shows the closed position. Fig. 3c shows the side view of the system 100'. 35 The below description of the system 100' starts from the assumption that a rotatable sun visor 18' comparable to the sun visor 18 having the joint 26 is used; note that this concept

of the audio transducer system 100' may also be useable in combination with other types of sun visors.

The spatial audio transducer system 100' combines an acoustically transparent sun visor 18' with a loudspeaker array 20' (comparable to the loudspeaker array 20 or 20*) mounted at the headlining 24 behind the closed sun visor (cf. Fig. 3c, sun visor 18' illustrated by broken lines). The loudspeakers 20' do not need to be integrated into the roof interior but can be. Given that the frame of the sun visor 18' is small enough, it will not influence the loudspeaker radiation property significantly. Hence, this variant could have a high technical merit.

In case the acoustically transparent sun visor 18' influences the sound or the sound quality of the array 20', it may be an option to adapt the sound signal of the transducers of the array 20' dependent on a detected open or closed position of the sun visor 18'. Therefore, this embodiment of the spatial audio transducer system 100' maybe combined with the sensor or angle sensor 30 as described with respect to Fig. 2.

Fig. 4 shows a system 100'', wherein Fig. 4a shows the passenger's view of the open sun visor 18'', Fig. 4b shows a passenger's view of the closed sun visor 18'' and Fig. 4c shows a corresponding side view of the open and the closed position of the sun visor 18''. This sun visor 18'' may have a recess at the edge for the joint 26'' in which the audio transducer array 20'' is arranged. The loudspeaker array 20'' (comparable to the loudspeaker arrays 20, 20*, 20') is positioned near the rotation axis of the sun visor. For example, the joint 26 is replaced by a joint 26'' comprising the plurality of 20a to 20g. In such a configuration 100'', the sun visor 18'' is likely to significantly influence a sound field emitted by the loudspeakers 20a to 20g. However, such an influence can be considered when determining the filters implementing the chosen reproduction technique such that the desired acoustic scene can still be reproduced. Here, also the sensor 30, that determines the actual position of the sun visor 18'' and provides information to an algorithm that adapts the filters, may be used. It is still expected that the audio reproduction having an optimized reproduction will be convincing without such a measure in many cases.

Fig. 5 shows a spatial audio transducer system 100''' with the three views, passenger view open (a), passenger view closed (b), and side view (c). Here, the sun visor complies with the sun visor 18 of Fig. 2, and the transducer array complies with the transducer

array 20 of Fig. 2. However, in this embodiment the sun visor 18 is coupled to the headlining 24 or the windshield 28 using a rail 26'''. Due to the rail 26''' the sun visor 18 is movable along the rail 26''' instead of rotated. The sun visor 18 is, for example, coupled with the rail 26''' via slight bearings or another linear guiding. This has the advantage that there is always the same side of the sun visor 18 facing the occupants, where the loudspeaker array 20 can be built in.

Fig. 6 shows a spatial audio transducer system 100'''' in the three views, passenger open (a), passenger closed (b) and side view (c). Here, the arrangement of the sun visor 18'''' complies with the arrangement of the sun visor 18 of Fig. 2. Thus, the sun visor 18'''' is rotatable around the axis of the joint 26. However, in this embodiment the loudspeaker array 20'''' is integrated into the sun visor 18'''', wherein same emits the sound via an opening 32 arranged at an edge of the sun visor 18'''' opposite to the edge of the joint 26. This position of the sound source enables that the opening 32 is at least partially directed to the passenger without the dependency of the position of the sun visor 18'''. This is illustrated by Fig. 6c.

Fig. 7 shows, using the three views 7a, 7b and 7c, a spatial audio transducer system 100'''' which substantially complies with the system 100, wherein two loudspeaker arrays 20'''' and 21'''' are integrated into the sun visor 18. Here, the loudspeaker array 20'''' is integrated into a first main surface of the sun visor 18 opposite to a second main surface of the sun visor 18 facing to the headlining 24 at a closed position of the sun visor 18. The second array 21'''' is integrated into the second main surface. That is, the sun visor is equipped with two loudspeaker arrays on both sides. Dependent on the position of the sun visor 18, the respective loudspeaker array 20'''' or 21'''' facing to the passenger is activated, wherein the other loudspeaker array 20'''' or 21'''' is the deactivated. Here, the position sensor 30 may be beneficial because the signals ideally emitted by the loudspeakers on both sides will strongly be dependent on position the sun visor 18. In the extreme case of a fully opened or fully closed sun visor 18, the loudspeaker 21'''' facing the ceiling 24 or the loudspeakers 20'''' facing the windshield 28 will be turned off.

An alternative variant would be to use built in loudspeaker drivers radiating to both sides of the sun visor 18, as explained with respect to Fig. 2. There, the sensor 30 is used as a switch to reverse the phase of the radiating signal, according to the side of the sun visor 18 facing to the occupant.

Here, it should be noted that the position sensor 30, as discussed with respect to the Fig. 2a-2c and, is more important for the embodiments 100''', 100'''' and 100'''''.

Even though all of the above embodiments show one-dimensional loudspeaker arrays, i.e. line arrays having a longitudinal extension along the elongated shape of the sun visor 18, the embodiments are not limited to this configuration. Moreover, it is possible to use two-dimensional loudspeaker arrays, i.e. planar arrays, as illustrated by Figs. 8a to 8c (passenger's view open sun visor, passenger's view closed sun view, and side view).

Figs. 8a to 8c show a spatial audio transducer system 100'''''' which substantially complies with the spatial audio transducer system 10''', wherein a two-dimensional spatial audio transducer array 20'''''' is integrated into the sun visor 18. Here, the loudspeaker array 20'''''' comprises two line arrays, each comprising seven loudspeakers 20a to 20g. It should be noted that the transducers of the two dimensional array may be arranged within a plane or within a curved plane, e.g. curved around an edge of the sun visor 18.

According to a further embodiment, the spatial audio transducer system comprises an audio processor enabling to process the plurality of audio signals for the plurality of transducers 26a to 26g, dependent on the relative position to the passenger, wherein the position of each transducer may be described based on a straight or curved line or a mathematical function describing the straight or curved line, wherein the function depends on a recent position of the sun visor.

The audio processor may be configured to process the audio signals according to beamforming or spotforming algorithms, according to wavefield synthesis algorithms or, in general, according to another algorithm type enabling spatial audio reproduction. Here, a preferred embodiment is multizone audio reproduction which is typically based on so-called spotforming technique (related to beamforming). Spotforming enables to direct sound to a predefined point in space, wherein beamforming enables to emit sound within in certain direction along which a sound field is generated. Thus, the two techniques enabling spatial audio reproduction stay in close relationship to each other.

According to further embodiments, the loudspeaker arrays integrated into the sun visor may be combined with further loudspeakers integrated into the vehicle, for example loudspeakers integrated into the dashboard or into the door in order to enhance the frequency range of the system.

Furthermore, according to further embodiments, a vehicle comprises at least two spatial audio transducer systems, namely both integrated into the sun visors of the driver and of
5 the assistance driver.

Claims

1. Spatial audio transducer system (100, 100', 100'', 100''', 100''''', 100''''') comprising:

5 a sun visor (18a, 18b, 18, 18', 18'', 18''') of a vehicle; and

a spatial audio transducer array (20, 20*, 20', 20'', 20''', 20''''', 21''''', 20''''')
comprising at least three individual audio transducers (20a-20g), wherein the
spatial audio transducer array (20, 20*, 20', 20'', 20''', 20''''', 21''''', 20''''') is
10 integrated into the sun visor (18a, 18b, 18, 18', 18'', 18''') or into a headlining (24)
of the vehicle (10) such that same overlaps at least partially with the sun visor
(18a, 18b, 18, 18', 18'', 18''') at a closed position of the sun visor.
2. Spatial audio transducer system (100, 100', 100'', 100''', 100''''', 100''''') according
15 to claim 1, wherein the at least three individual audio transducers (20a-20g) are
loudspeakers.
3. Spatial audio transducer system (100, 100', 100'', 100''', 100''''', 100''''') according
20 to claim 2, further comprising a spatial processor configured to process at least
three audio signals via which the at least three audio transducers (20a-20g) are
controlled in order to optimize the directional reproduction.
4. Spatial audio transducer system (100, 100', 100'', 100''', 100''''', 100''''') according
25 to claim 3, wherein the spatial audio transducer system is configured to perform
beamforming.
5. Spatial audio transducer system (100, 100', 100'', 100''', 100''''', 100''''') according
to one of the claims 1 to 5, further comprising a sun visor sensor (30) and a sound
processor, wherein a sun visor sensor is configured to detect a position of the sun
30 visor (18a, 18b, 18, 18', 18'', 18''') and wherein the sound processor is configured
to process audio signals for the audio transducers (20a-20g) dependent on the
detected position of the sun visor.
6. Spatial audio transducer system (100, 100', 100'', 100''', 100''''', 100''''') according
35 to claim 5, wherein the sound processor comprises one or more filters and wherein

filter coefficients of the filters are adapted dependent on the detected position of the sun visor.

7. Spatial audio transducer system (100, 100', 100'', 100''', 100''''', 100''''') according to claim 5 or 6, wherein the sun visor sensor (30) is an angle sensor.
8. Spatial audio transducer system (100, 100', 100'', 100''', 100''''', 100''''') according to one of claims 1 to 7, wherein the spatial audio transducer array (20, 20*, 20', 20'', 20''', 20''''', 21''''', 20''''') is integrated into the sun visor (18a, 18b, 18, 18', 18'', 18''') and wherein the sun visor (18a, 18b, 18, 18', 18'', 18''') comprises an opening at an edge of the sun visor (18a, 18b, 18, 18', 18'', 18''') which is arranged opposite to an edge comprising a joint (26, 26'') of the sun visor.
9. Spatial audio transducer system (100, 100', 100'', 100''', 100''''', 100''''') according to one claims 1 to 7, wherein the spatial audio transducer array (20, 20*, 20', 20'', 20''', 20''''', 21''''', 20''''') is integrated into the headlining (24) and wherein the sun visor (18a, 18b, 18, 18', 18'', 18''') comprises an acoustically transparent material.
10. Spatial audio transducer system (100, 100', 100'', 100''', 100''''', 100''''') according to one of claims 1 to 7, wherein the sun visor (18a, 18b, 18, 18', 18'', 18''') is coupled to the headlining (24) at joint (26, 26'') of the sun visor.
11. Spatial audio transducer system (100, 100', 100'', 100''', 100''''', 100''''') according to claim 10, wherein the spatial audio transducer array (20, 20*, 20', 20'', 20''', 20''''', 21''''', 20''''') is integrated into the joint (26, 26'') of the sun visor.
12. Spatial audio transducer system (100, 100', 100'', 100''', 100''''', 100''''') according to one of claims 1 to 11, wherein the spatial audio transducer array (20, 20*, 20', 20'', 20''', 20''''', 21''''', 20''''') is arranged in a first main surface opposite to a second main surface facing the headlining (24) at the closed position of the sun visor.
13. Spatial audio transducer system (100, 100', 100'', 100''', 100''''', 100''''') according to claim 12, further comprising a further spatial audio transducer array (20, 20*, 20', 20'', 20''', 20''''', 21''''', 20''''') arranged at the second main surface, wherein the spatial audio transducer array (20, 20*, 20', 20'', 20''', 20''''', 21''''', 20''''') is

activated at the closed position of the sun visor (18a, 18b, 18, 18', 18'', 18''') and wherein the further spatial audio transducer array (20, 20*, 20', 20'', 20''', 20''''', 21''''', 20''''''') is activated at an open position of the sun visor.

- 5 14. Spatial audio transducer system (100, 100', 100'', 100''', 100''''', 100''''''') according to one of the claims 1 to 9, wherein the sun visor (18a, 18b, 18, 18', 18'', 18''') is coupled to the headlining (24) using one or two rails (26'''), and wherein the spatial audio transducer array (20, 20*, 20', 20'', 20''', 20''''', 21''''', 20''''''') is arranged at a first main surface opposite to a second main surface facing the headlining (24) at
10 the closed position of the sun visor.
- 15 15. Spatial audio transducer system (100, 100', 100'', 100''', 100''''', 100''''''') according to one of claims 1 to 14, wherein the spatial audio transducer array (20, 20*, 20', 20'', 20''', 20''''', 21''''', 20''''''') comprises a line array.
- 20 16. Spatial audio transducer system (100, 100', 100'', 100''', 100''''', 100''''''') according to one of claims 1 to 15, wherein the Spatial audio transducer array (20, 20*, 20', 20'', 20''', 20''''', 21''''', 20''''''') is a two-dimensional array (20''''''') arranged within a plane or a curved plane.
- 25 17. Spatial audio transducer system (100, 100', 100'', 100''', 100''''', 100''''''') according to claim 1, wherein at least one of the three individual audio transducers (20a-20g) is a microphone.

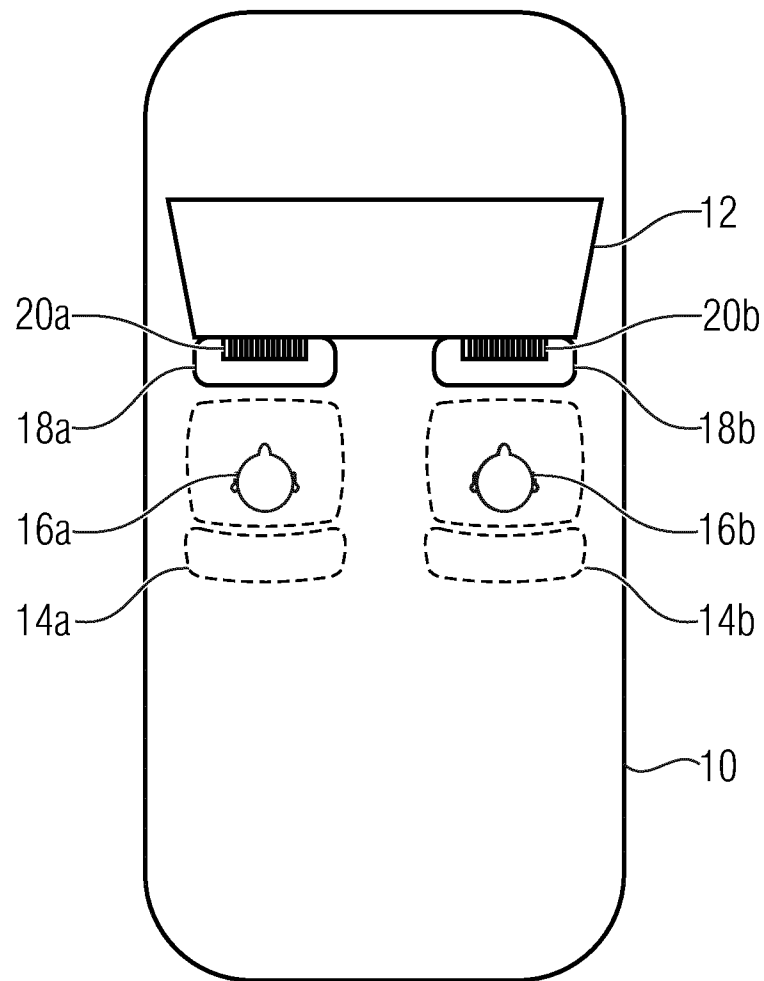


FIG 1A

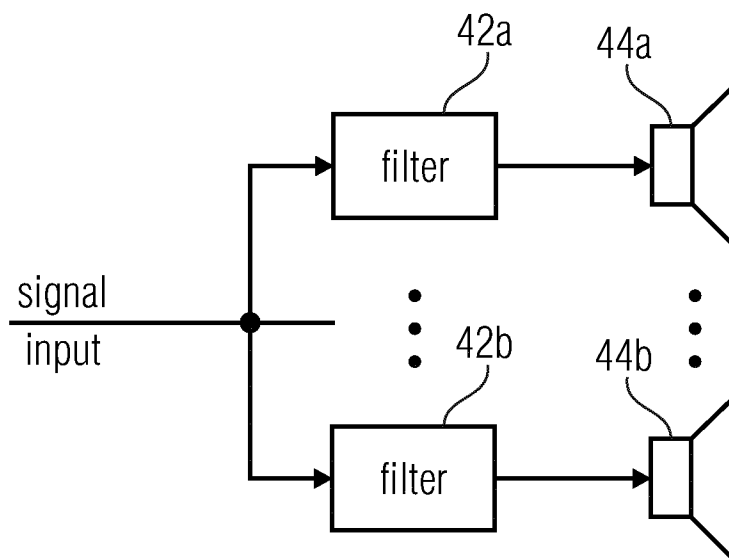


FIG 1B

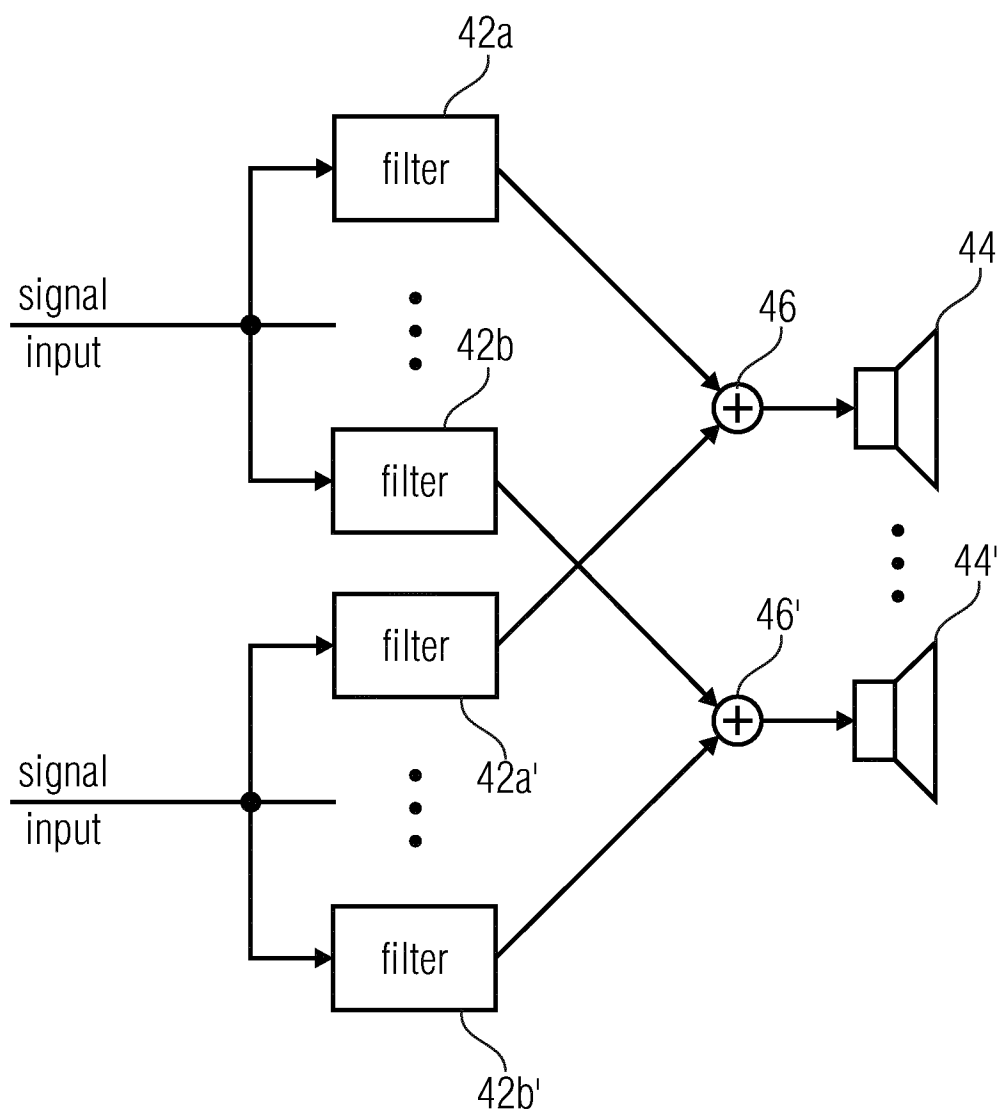


FIG 1C

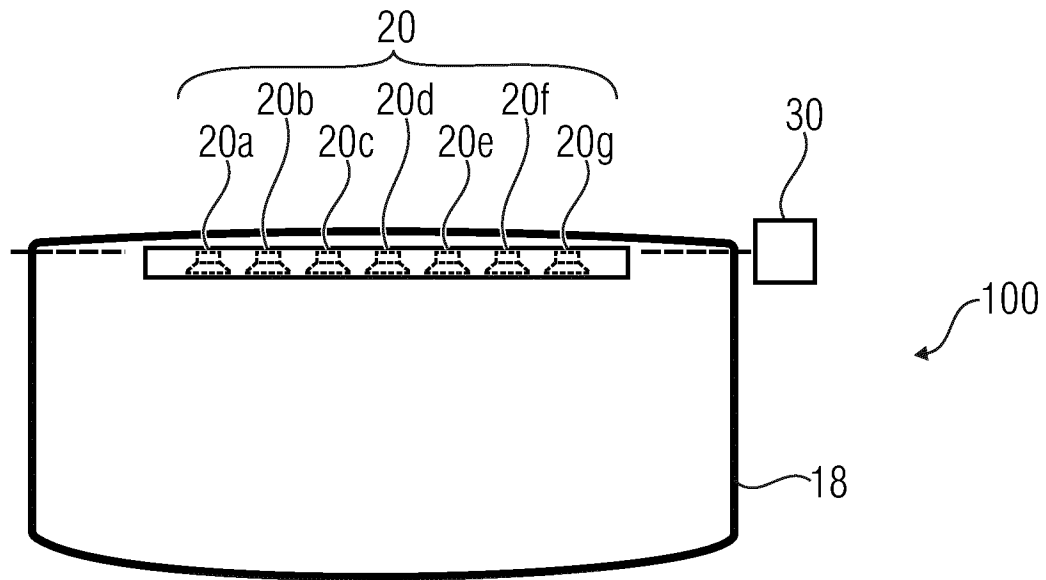


FIG 2A

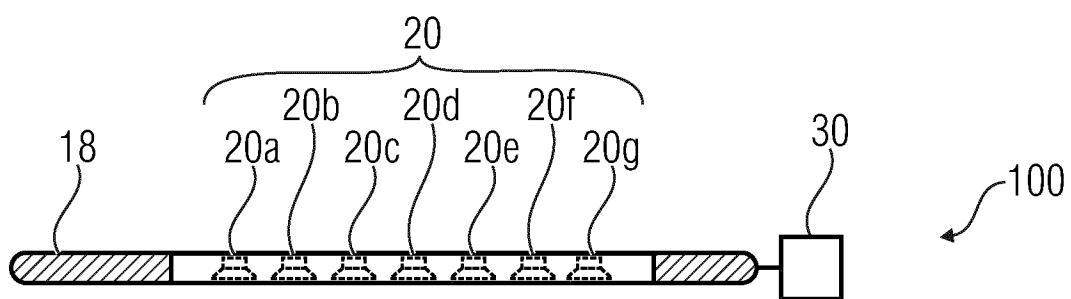


FIG 2B

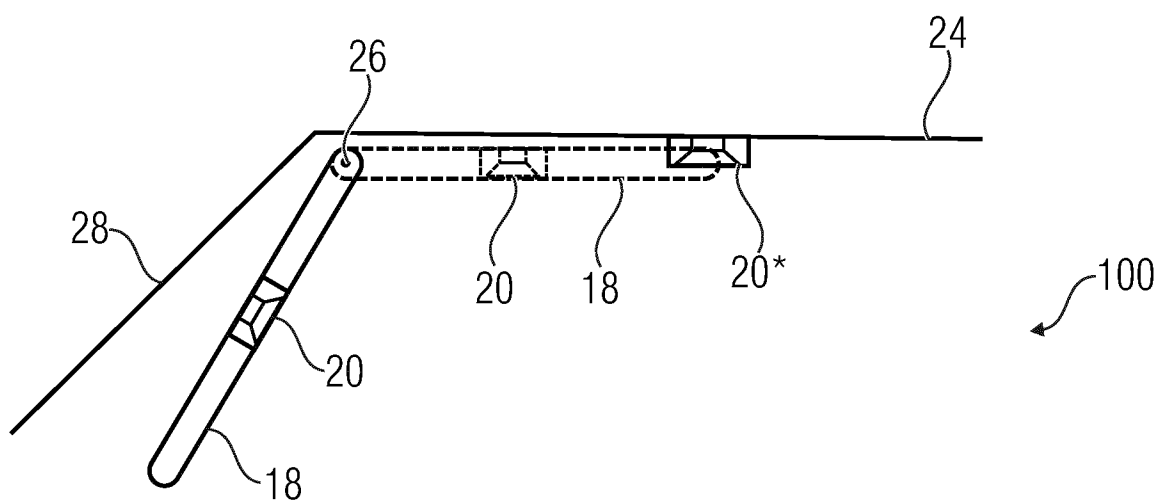


FIG 2C

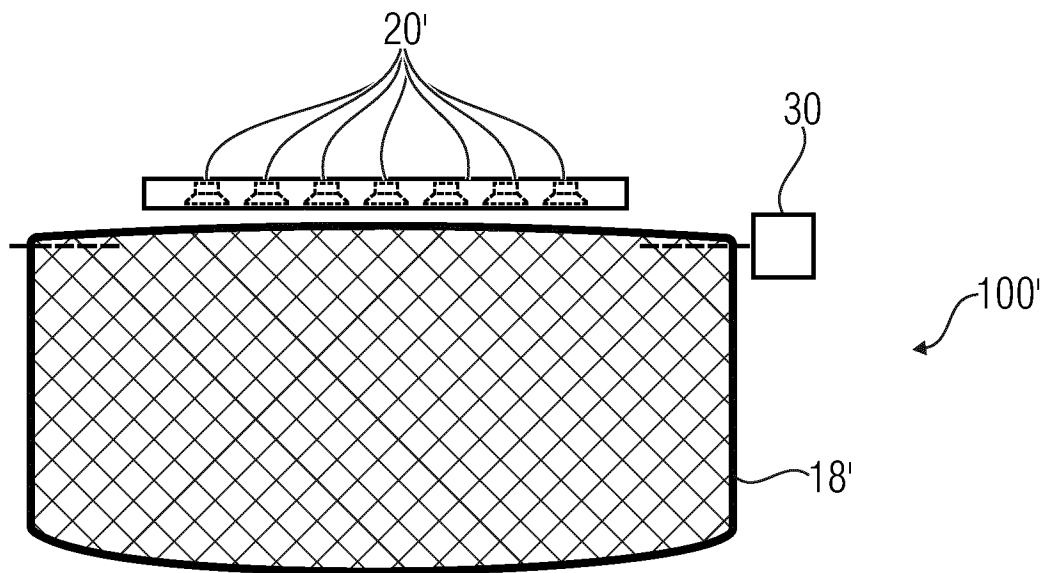


FIG 3A

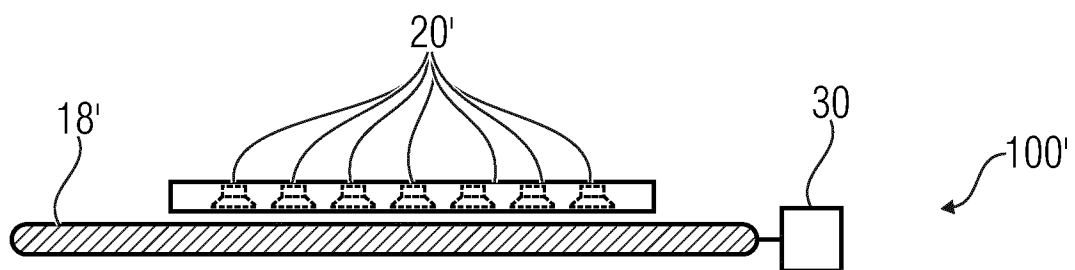


FIG 3B

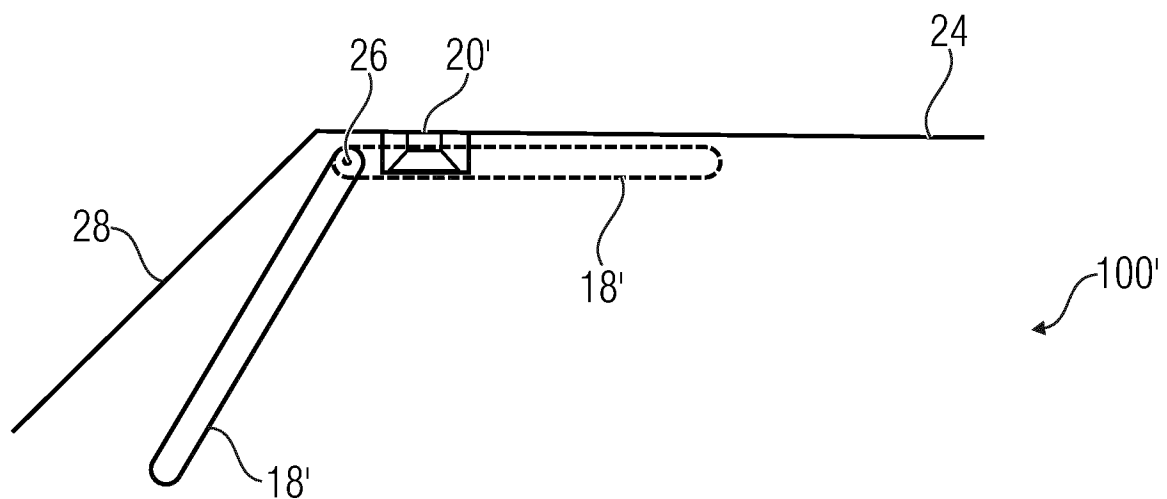


FIG 3C

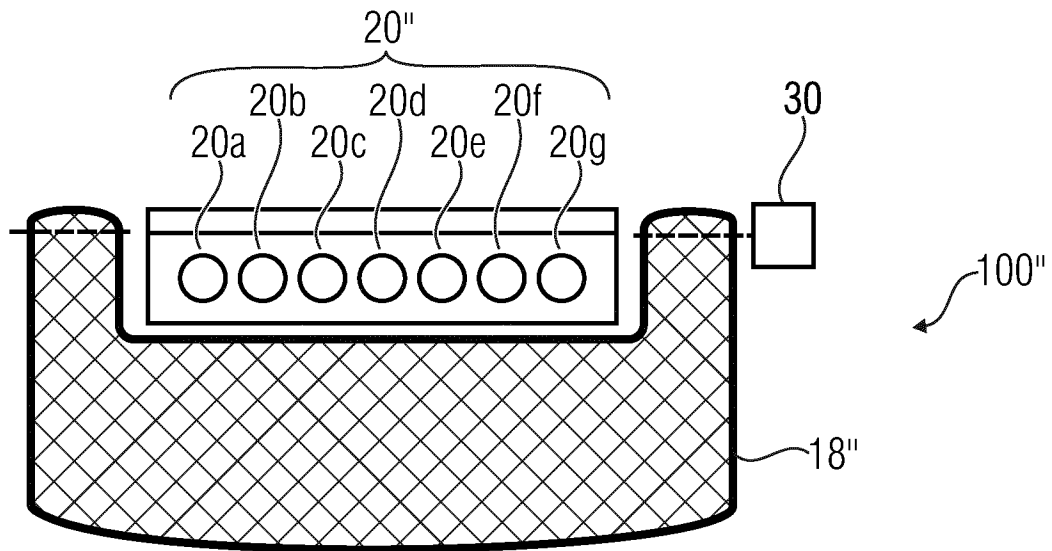


FIG 4A

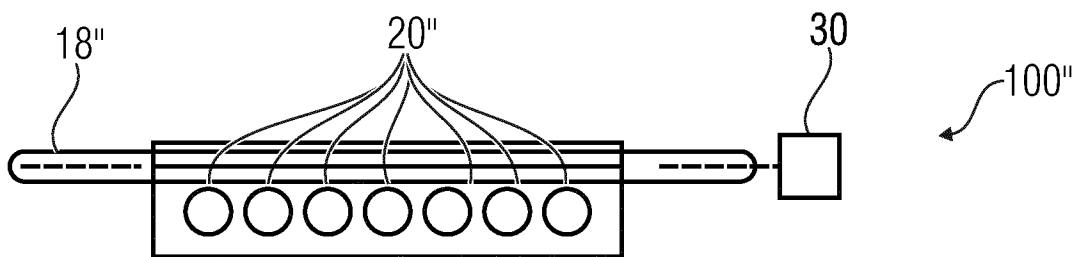


FIG 4B

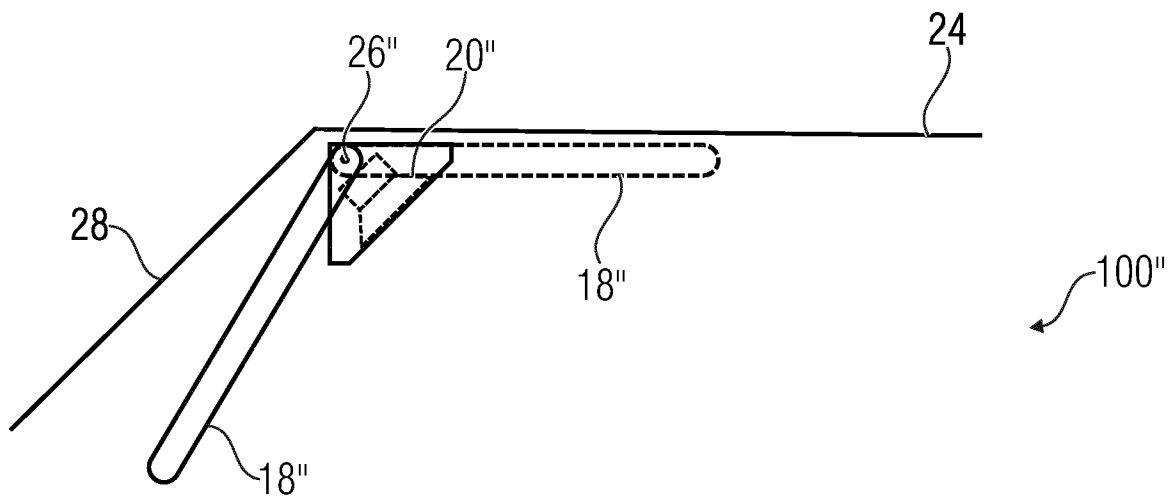


FIG 4C

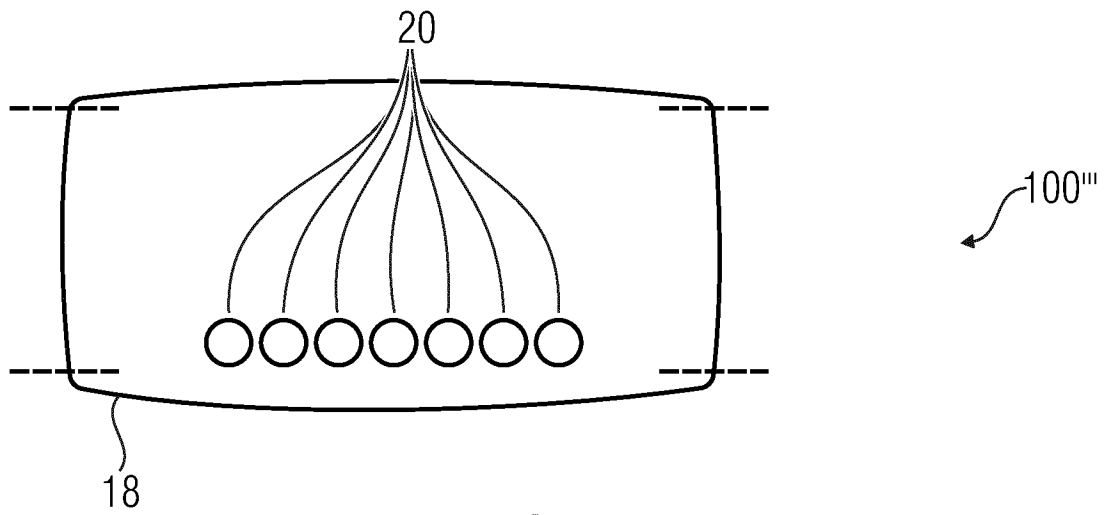


FIG 5A

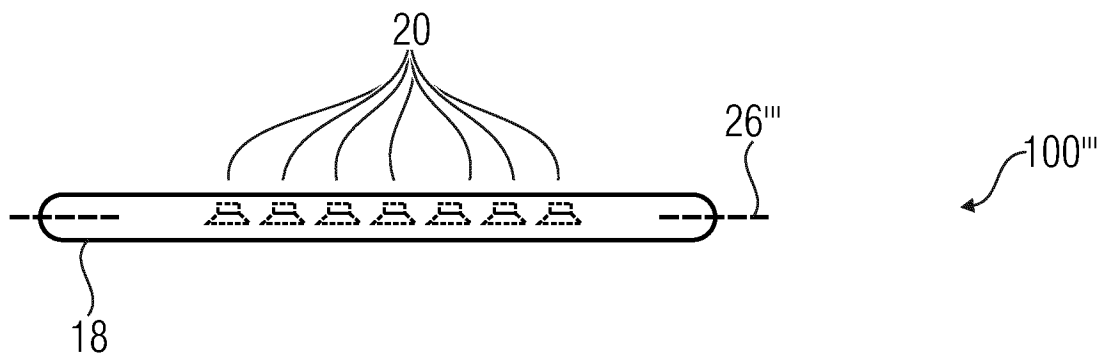


FIG 5B

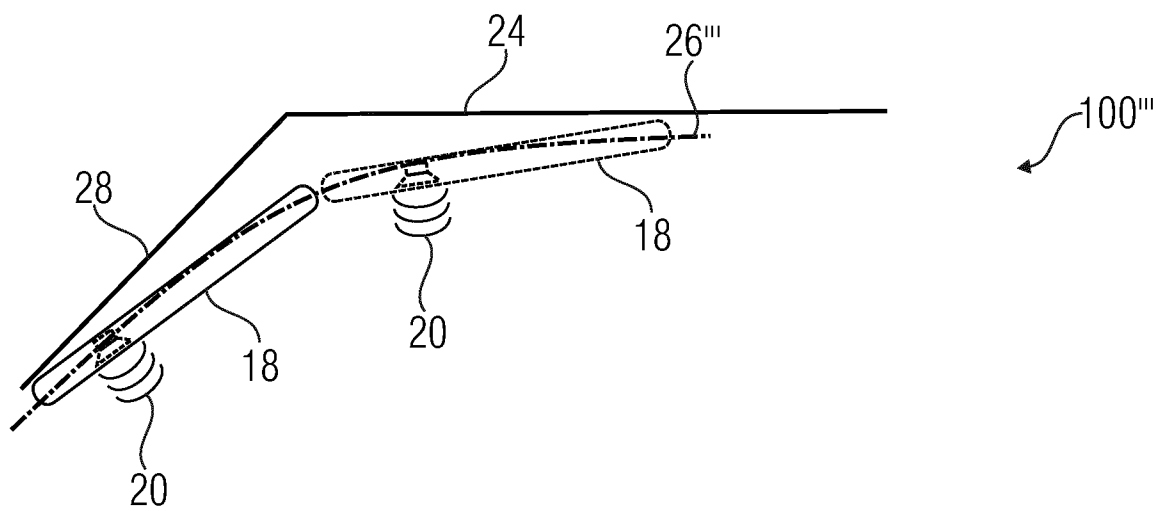


FIG 5C

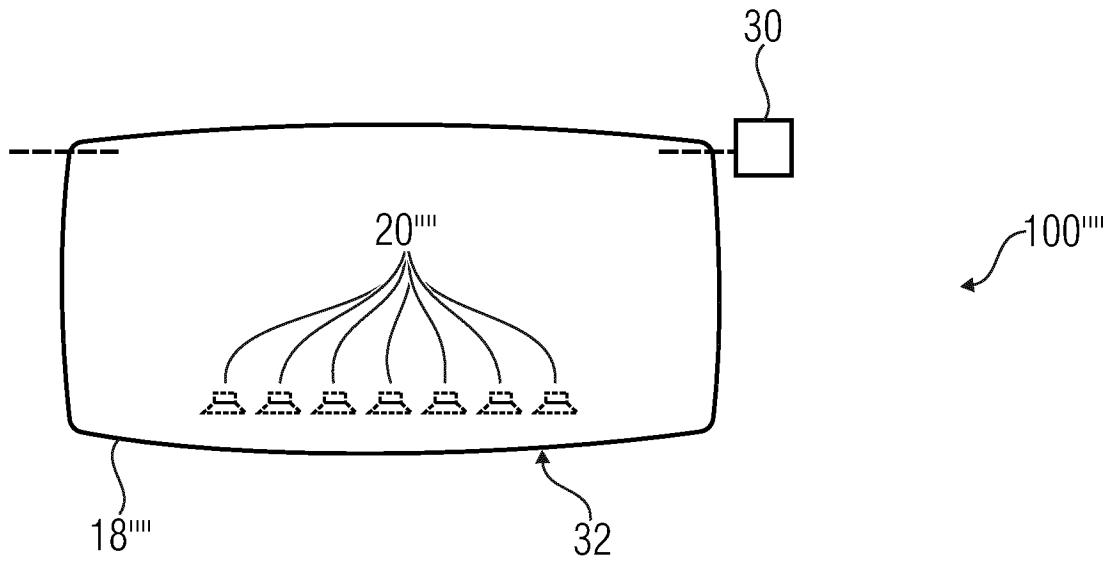


FIG 6A

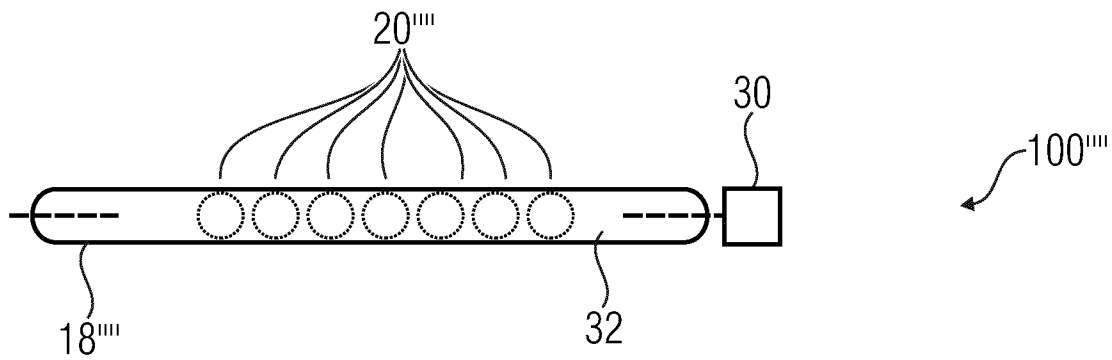


FIG 6B

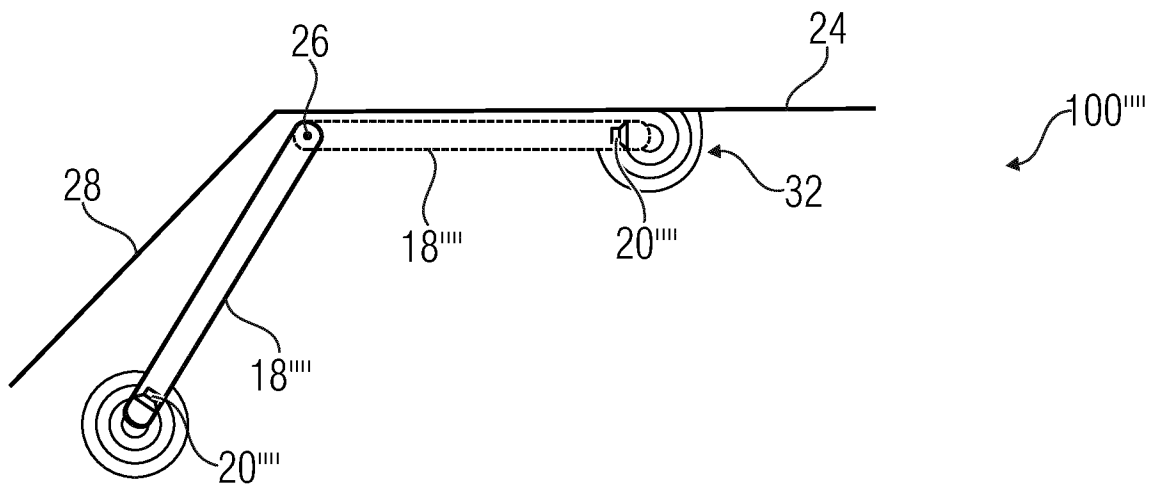


FIG 6C

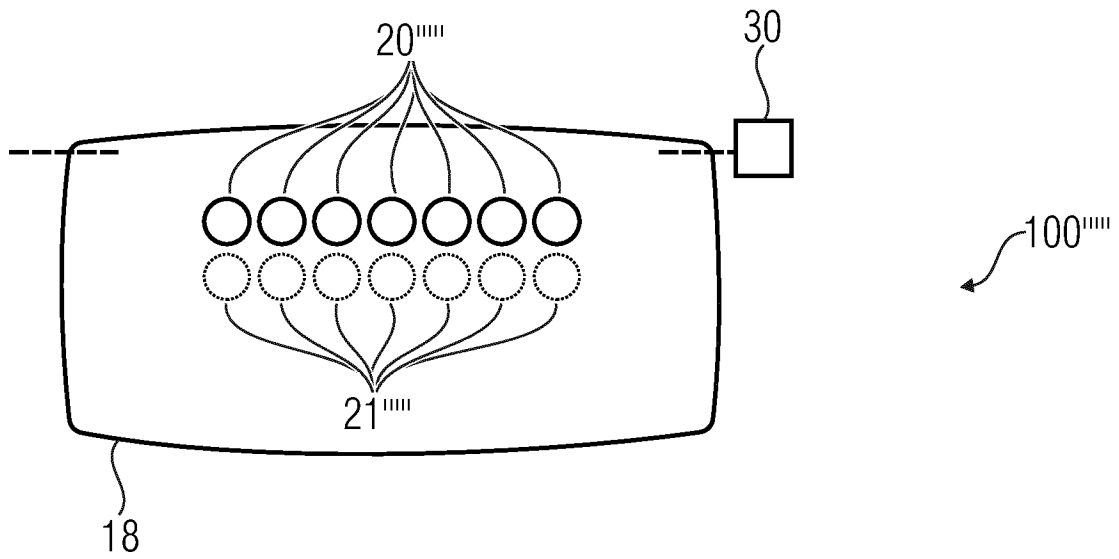


FIG 7A

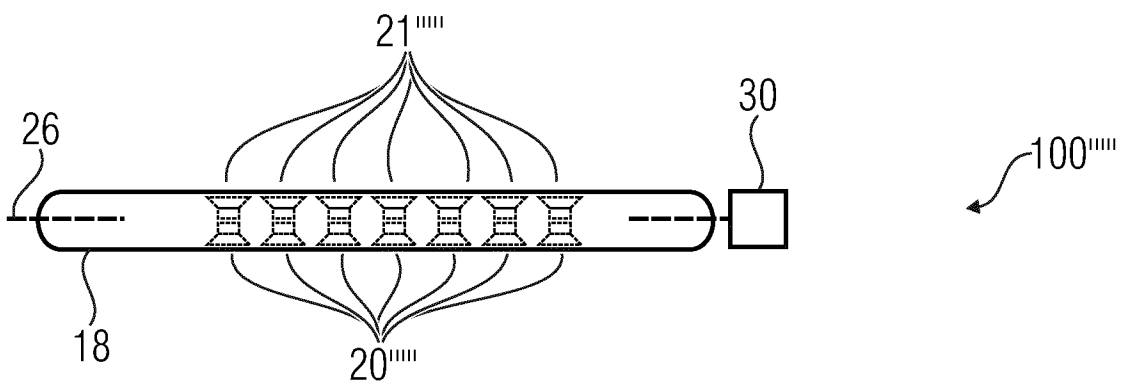


FIG 7B

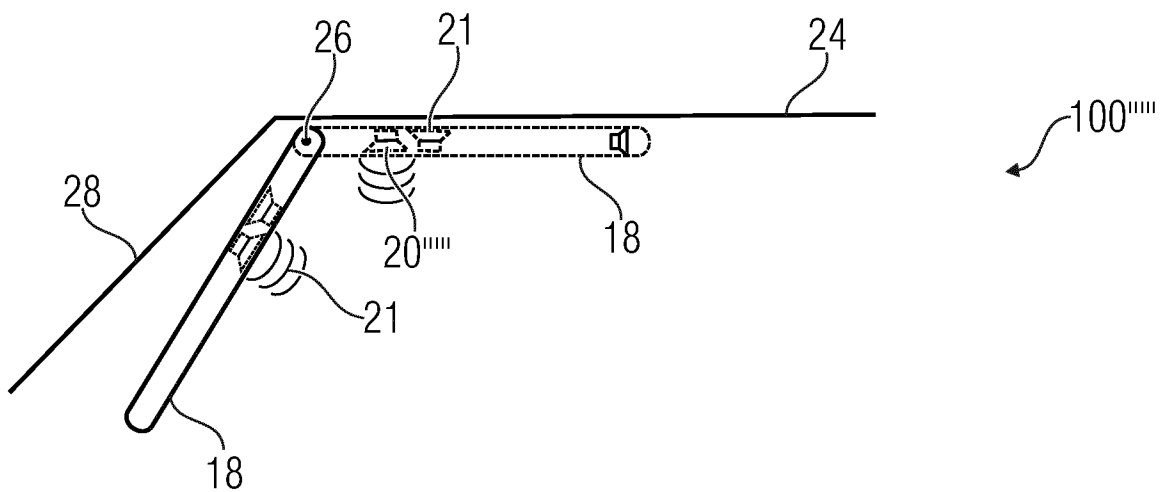


FIG 7C

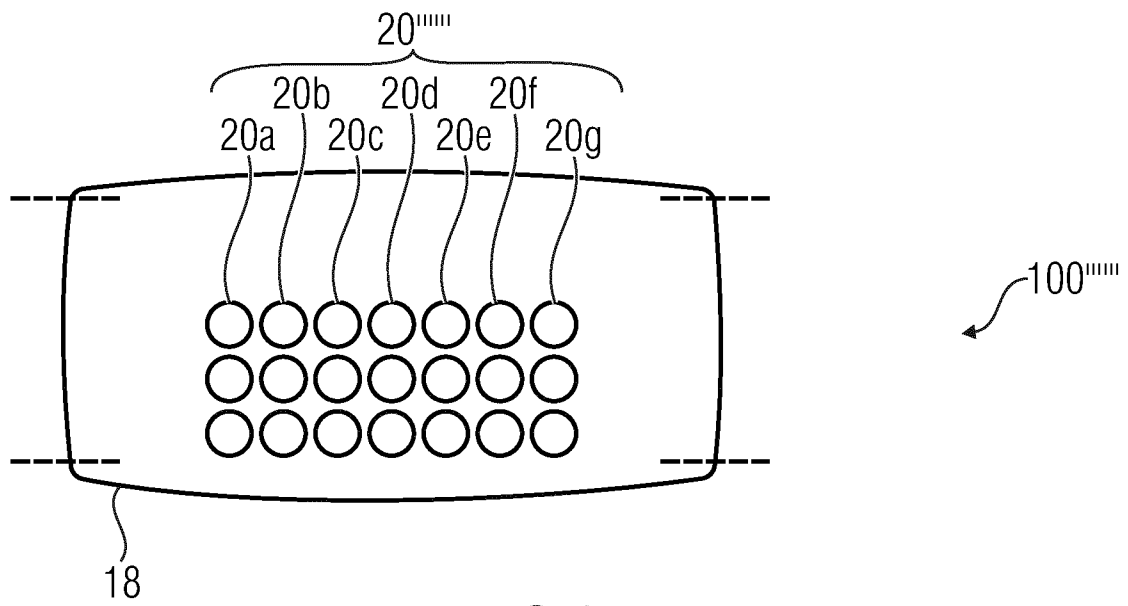


FIG 8A

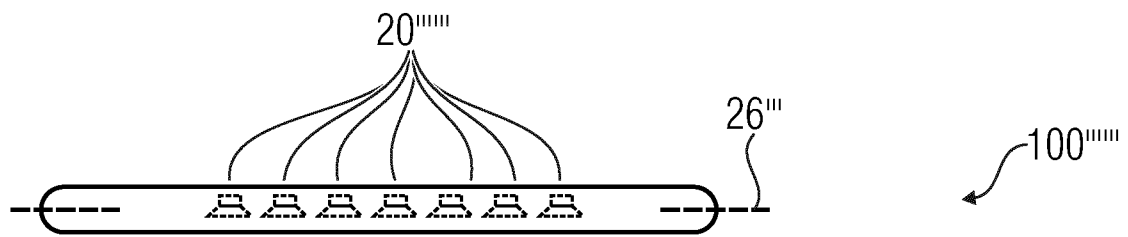


FIG 8B

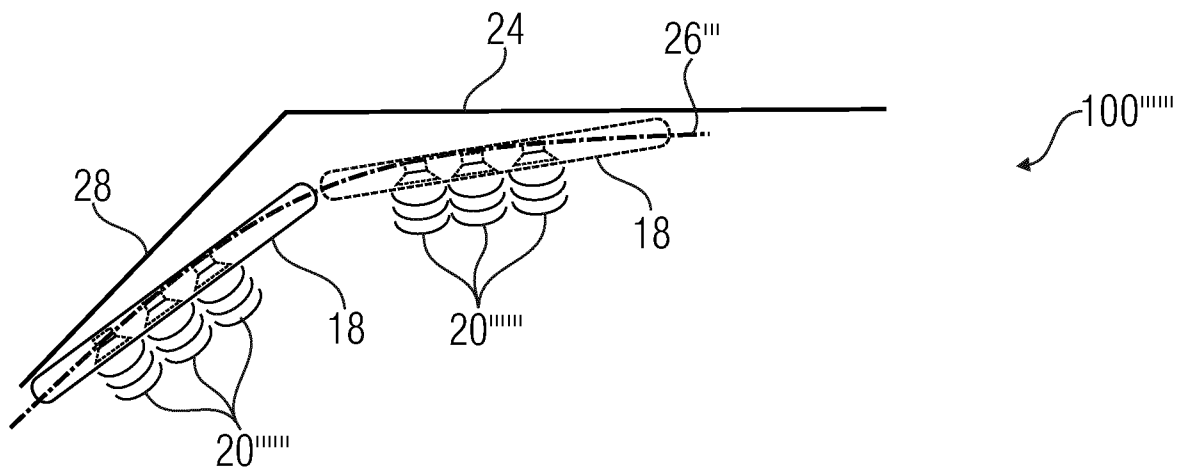


FIG 8C

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2016/051924

A. CLASSIFICATION OF SUBJECT MATTER INV. H04R1/40 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) H04R B60J		
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 6 959 956 B1 (FERO MARK W [US] ET AL) 1 November 2005 (2005-11-01) column 2, line 56 - column 3, line 16; figure 1 column 3, line 59 - line 64; figure 3 column 4, line 34 - line 39; figure 2 -----	1,2,9, 12-17
X	US 2008/192953 A1 (OPFER HOLGER [DE]) 14 August 2008 (2008-08-14) paragraph [0024]; figure 1 -----	1-4
X	US 5 442 813 A (WALTERS ECKHARD [DE]) 15 August 1995 (1995-08-15) column 1, lines 33-37, 51-55, 65-67 column 4, lines 7-42; figures 1,2 ----- -/-	1,2,8, 10,11, 15,17
☒ Further documents are listed in the continuation of Box C. ☒ See patent family annex.		
* Special categories of cited documents : "A" document defining the general state of the art which is not considered to be of particular relevance "E" earlier application or patent but published on or after the international filing date "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but later than the priority date claimed "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention "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 "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art "&" document member of the same patent family		
Date of the actual completion of the international search 5 April 2016		Date of mailing of the international search report 18/05/2016
Name and mailing address of the ISA/ European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016		Authorized officer Fobel, Oliver

INTERNATIONAL SEARCH REPORT

International application No

PCT/EP2016/051924

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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X	US 2013/336518 A1 (YAMAUCHI KENJI [JP] ET AL) 19 December 2013 (2013-12-19) paragraphs [0030], [0122]; figures 1,12 -----	1,2,15
X	JP S58 56940 A (FUJITSU TEN LTD) 4 April 1983 (1983-04-04) abstract; figure 1 -----	1,2,16
X	EP 2 822 292 A1 (GN NETCOM AS [DK]) 7 January 2015 (2015-01-07) paragraphs [0014], [0015], [0030] - [0037]; figures 5-7 -----	1,5-7, 12-17
X	US 2007/138825 A1 (LINHARD KLAUS [DE] ET AL) 21 June 2007 (2007-06-21) paragraph [0026]; figure 1 -----	1,9, 12-17

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

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