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(54) **ACOUSTIC TRANSDUCER**

(57) An acoustic transducer (1) comprising:
- a sound source (2) adapted to emit acoustic radiations along a prevalent emission axis (A2);
- a horn (10) coupled to the sound source (2) and having a hollow main body (11) which extends between an inlet opening (12) that receives said acoustic radiations and an outlet opening (13) for their external broadcasting. The main body (11) has walls (14-17) which delimit a flared conduit having a variable section which allows the propagation of the acoustic radiations between the inlet opening (12) and the outlet opening (13). The main body (11) extends along a prevalent longitudinal extension axis (A10) misaligned with respect to the prevalent emission axis (A2).

The horn (10) comprises, inside the flared conduit, obstacles (101,102) or partition elements (103) which locally narrow its section in at least two transverse directions (D11-D12) with respect to the prevalent longitudinal extension axis (A10).

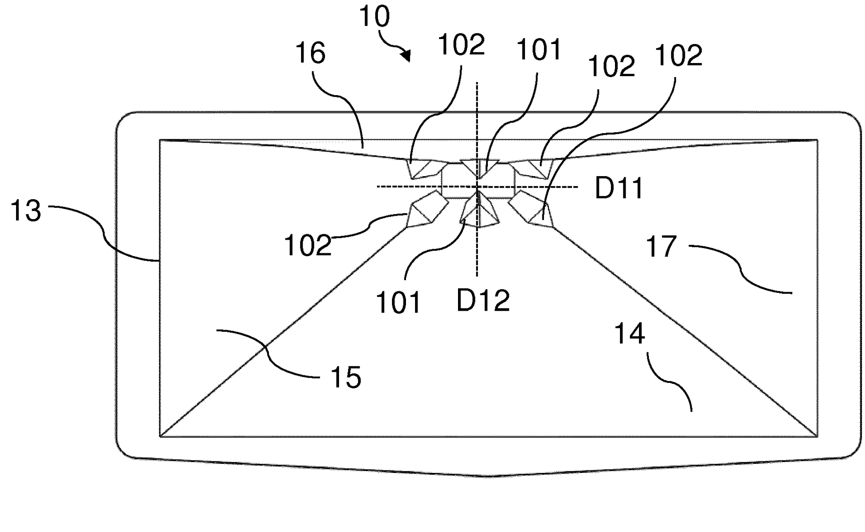

FIG. 4

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Description

FIELD OF THE INVENTION

[0001] The present invention relates to the technical field of audio reproducing systems and relates to an acoustic transducer, particularly but not exclusively for road tunnels.

BACKGROUND ART

[0002] An acoustic transducer is a device of an audio system adapted to convert an electrical signal into acoustic waves. A particular type of acoustic transducer comprises at least one sound source, such as for example a compression driver and an acoustic waveguide, referred to as a horn.

[0003] An acoustic waveguide, or horn, comprises an internally hollow main body, which extends between an inlet opening adapted to receive an acoustic radiation and an outlet opening for the diffusion of said radiation outside the acoustic waveguide. The main body of the acoustic waveguide has inner walls which delimit a flared conduit which allows the propagation of the acoustic radiation between the inlet opening and the outlet opening. The inlet opening is generally referred to as a throat and the outlet opening is generally referred to as a mouth. The main body extends along an axis having prevalent longitudinal extension, referred to as a main axis of the horn.

[0004] In some applications, e.g. if the acoustic transducer is installed either near or adjacent to an installation wall and/or if two or more acoustic sources are coupled to a single shared horn, the sound source and the horn must be coupled so that the prevalent acoustic emission axis of the sound source is misaligned with respect to the horn axis. Some examples of acoustic transducers of this type are described in US 2,135,610 A or in US 8,995,700 B2.

[0005] The aforesaid misalignment determines a deterioration of the sound quality with respect to an ideal situation in which the main axis of the horn and the prevalent emission axis of the acoustic source are aligned, e.g. mutually coincide. This is due to the fact that the acoustic radiation reflections on the inner walls of the horn allow the undesired propagation of higher acoustic modes. This problem is felt, in particular, but not exclusively, in the diffusion systems of a voice signal because it significantly afflicts speech intelligibility, e.g. measured by means of the STI (Speech Transmission Index) technique.

[0006] A road tunnel is a covered and confined infrastructure intended for the transit of vehicles.

[0007] The main directives in matter of safety, on national and supranational level, require the installation of sound diffusion systems for playing voice messages in emergency conditions and when it is necessary to evacuate the tunnel.

[0008] However, road tunnels are an acoustically hostile environment for sound broadcasting, because of the materials used for building them, their geometry, long reverberation times, as well as the background noise conditions generated by vehicle traffic and the ventilation systems.

[0009] The speech intelligibility level, specifically of voice messages played by a broadcasting system, evaluated by measuring the STI (Speech Transmission Index), as described in international standard IEC60268-16:2011.

[0010] Current road tunnel public address systems, where present, consist of a succession of small-size, traditional, commercial horn transducers placed by the side of the carriageway and mutually distanced; in general, this solution produces very modest intelligibility values of speech on carriageway.

[0011] It is an object of the present invention to provide an acoustic transducer which allows to solve or in least in part reduce the drawbacks described above with reference to the acoustic transducers of the known art described above.

[0012] It is a further object of the present invention to provide an acoustic transducer, belonging to a complete public address systems, designed to considerably increase speech intelligibility, in particular for broadcasting emergency messages in road tunnels.

[0013] Such objects are achieved by an acoustic transducer as defined in general in claim 1. Alternative preferred and advantageous embodiments of the aforesaid acoustic transducer are defined in the appended dependent claims. A further object is solved by a sound and/or voice message broadcasting system in a road tunnel, as defined in claim 16.

[0014] The invention will be better understood by means of the following detailed description of a particular embodiment, made by way of example and thus not limiting in any manner, with reference to the accompanying drawings which are briefly described in the following paragraph.

BRIEF DESCRIPTION OF THE DRAWINGS

[0015]

Figure 1 shows a perspective view from the top of a non-limiting embodiment of an acoustic transducer, comprising a horn and two sound sources coupled to the horn.

Figure 2 is a perspective view, with parts separated, of the acoustic transducer in figure 1.

Figure 3 shows an enlarged part of figure 2.

Figure 4 shows a front plan view of a first possible embodiment of the horn of the acoustic transducer in figure 1.

Figure 5 is a rear flat view of the horn in figure 4.

Figure 6 is a perspective section view of the horn in figure 4.

Figure 7 shows a front plan view of a second possible embodiment of the horn of the acoustic transducer in figure 1.

Figure 8 is a perspective section view of the horn in figure 7.

DETAILED DESCRIPTION

[0016] Figure 1 shows an embodiment by way of non-limiting example of an acoustic transducer 1, which is an electro-acoustic transducer in particular.

[0017] In the particular embodiment shown, the acoustic transducer 1 comprises two sound sources 2 and a horn 10, which are mutually coupled, e.g. by means of a mechanical coupling system. The teachings of the present description can be applied also to an acoustic transducer 1 which has a single sound source 2 or more than two sound sources 2, and therefore it is possible to say that in a general embodiment the acoustic transducer 1 comprises at least one sound source 2. For the aforesaid reasons, in the present invention reference will be made indifferently to an acoustic transducer 1 having a single sound source 2 or having multiple sound sources 2.

[0018] The aforesaid sound source 2 is, for example, a compression driver and is adapted to emit an acoustic radiation along a prevalent emission axis A2. For example, such an acoustic radiation is a spherical wave acoustic radiation centered about such an axis A2 which propagates along such an axis A2 in the emission sense.

[0019] In particular, the acoustic transducer 1 is a transducer intended to be suspended from an installation wall, either in contact with it or at a short distance from it, in order to reduce the effect of the reflections on the installation wall as much as possible, as described in patent US 2,135,610 A. For example, the aforesaid acoustic transducer 1 is comprised in an acoustic diffusion system comprising an array of acoustic transducers installed on the upper wall or on a ceiling of a tunnel, e. g. a road tunnel, for broadcasting sound and/or voice messages. However, the teachings suggested here are also applicable to other types of acoustic transducers, therefore the scope of protection must not be understood as limited to acoustic transducers which can be installed on wall.

[0020] The horn 10 has an internally hollow main body 11 which extends between an inlet opening 12 adapted to receive the acoustic radiation emitted by the sound source 2 and an outlet opening 13 for broadcasting such an acoustic radiation outside the main body 11. The inlet opening 12 is generally referred to as a throat, while the outlet opening 13 is generally referred to as a mouth.

[0021] The main body 11 has walls 14-17 which delimit a flared conduit, which allows the propagation of the emitted acoustic radiation between the inlet opening 12 and the outlet opening 13, i.e. between the throat and the mouth. The main body 11 of the acoustic transducer 1 extends along a prevalent longitudinal extension axis A10 which is misaligned with respect to the prevalent emission axis A2 of the sound source 2. Preferably, the outlet opening 13 has a quadrangular-shape, i.e. rectangular in the example. Preferably, the inlet opening 12 has a quadrangular-shape, i.e. rectangular in the example.

[0022] According to a preferred embodiment, the flared conduit is delimited by two mutually opposite walls 14,16 having mutually different shape. For example, as in the embodiment shown in the figures, one of said walls 16 is flat and the other of said walls 14 is at least partially curved. For example, the flat wall 16 is intended to be superimposed on an installation wall in contact with such an installation wall or arranged as close as possible to the latter. Preferably, the flared conduit is delimited by two mutually opposite walls 15,17 having the same shape. In the example, such further walls 15,17 are at least partially curved and mutually diverging, going from the inlet opening 12 towards the outlet opening 13.

[0023] The main body 11 may be made of plastic or metallic material, e.g. aluminum.

[0024] The horn 10 comprises, inside the flared conduit, one or more obstacles 101,102 or partition elements 103 which locally narrow the section of the flared body in at least two directions D11, D12 transverse with respect to the prevalent longitudinal extension axis A10. According to an embodiment, the horn 10 comprises at least two obstacles 101, 102 or at least two partition elements 103. The aforesaid at least two obstacles 101,102 or at least two partition elements 102 are preferably arranged in mutually opposite positions with respect to the prevalent longitudinal direction A10. In the example, with reference to figures 4 and 7, it is worth noting that the obstacles 101, 102 in figure 2 or the partition elements 103 in figure 7 narrow the cross section of the flared conduit of the main body 11 in direction D11 and in direction D12. For the purposes of the present description, narrowing of the section in at least two directions D11, D12 means either that the narrowing occurs along such directions or that it occurs along a direction parallel to such directions.

[0025] If partition elements 103 are included, the narrowing of the cross section of the flared conduit determines a subdivision of such a section into multiple subsections.

[0026] The local narrowing of the cross section of the horn alters the energy balance in favor of the fundamental mode and makes the higher modes evanescent for a wider frequency band. In the case of horn acoustic transducers for voice signal transmission, it has been observed that reducing the higher modes can significantly improve speech intelligibility measured by means of the STI (Speech Transmission Index) technique.

[0027] In practice, obstacles 101, 102 locally reduce the total surface which can be crossed by the acoustic radiation, by acting above all on the maximum pressure points of the higher modes, approaching them and promoting the evanescent mode phenomenon. The partition elements 103 divide the total surface into smaller surfaces, inside which the cutoff frequencies of the higher modes are higher.

[0028] Advantageously, if the acoustic radiation emitted by the sound sources 2 has a main mode and higher modes, the obstacles 101,102 or the partition elements 103 are such as to increase the cutoff frequency of the higher modes.

[0029] In most of the horns for speakers, operation is based on the propagation of the aforesaid "fundamental mode", i.e. a sound propagation mode in which each section of the horn is crossed by a single sound pressure wave front, coherent in amplitude and phase.

[0030] As in other oscillatory phenomena, also in acoustics the transverse dimension of the conduit limits the possible oscillation modes of the means (air in this case). The analysis is particularly simple for constant section rectilinear conduits: in this case, only the natural mode can propagate under a given cutoff frequency. The same higher mode "filtering" phenomenon occurs in all other cases - variable section conduits or with non-rectilinear propagation axis -, but with features which vary from point to point; additionally, the geometric variation tends to introduce transverse oscillation modes which were not present at the sound source 2. If higher oscillation modes are present in the sound field which cannot propagate because of the geometry of the conduit, these modes become evanescent, i.e. rapidly attenuate with exponential law, the further they are from the natural cutoff frequency, i.e. the frequency at which propagation becomes possible. Obstacles 101,102 or partition elements 103 are thus preferably adapted and configured to determine and/or promote higher mode evanescence.

[0031] So, for a constant section rectilinear conduit, the situation is the following: it is possible to identify a fundamental mode, which can propagate independently from signal frequency, and infinite transverse modes, each characterized by a natural cutoff frequency, i.e. the minimum frequency (which is thus an inferior cutoff frequency) to which the mode can propagate compatibly with the constraints, i.e. the walls of the conduit.

[0032] In an acoustic transducer horn, which typically defines a flared conduit having increasing cross section, the cutoff frequencies of the transverse mode gradually decrease proceeding from the inlet opening 12 towards the outlet opening 13.

[0033] We will assume the following situation: a horn 10 designed to impose a given angular coverage to the sound field, i.e. to radiate the sound towards the delimited and well-defined portion of space. We can also assume that design is based on the propagation of the fundamental mode only. Technical conditions may occur which cause the onset of transverse oscillation modes on sound source level. A typical case is the need, dictated by technical reasons, to position the sound sources misaligned with respect to the axis A10 of the prevalent longitudinal extension of the horn 10. In this condition, the sound energy emitted by the sound sources 2 will tend to reflect more on the walls 14-17 of the horn 10 and thus create a greater number of transversal modes or higher modes.

[0034] By virtue of the obstacle 101, 102 or the partition elements, the solution described above aims at reducing the impact of the transverse modes on the performance of the horn 10. The transverse modes completely cannot be removed completely if the operating band of the horn-source system (or horn-sources) is rather wide; the impact can be limited by moving their cutoff frequencies more upwards. In other words, the transverse mode cutoff frequencies are displaced more upwards, leaving the fundamental mode undisturbed in a wider frequency band.

[0035] The obstacles 101, 102 have the purpose of reducing the maximum transverse distances inside the horn as much as possible. In this manner, the higher mode cutoff frequencies are increased, making it more difficult for the sound wave to be reflected between the walls of the horn.

[0036] The partition elements 103 substantially obtain the same result by acting in slightly different manner. When two portions of a mutually offset transverse mode are conveyed into a smaller section conduit, they become evanescent and are exponentially attenuated. Therefore, at the outlet of the conduits having smaller section there is a smaller proportion of transverse modes with respect to the inlet.

[0037] If the horn 10 is provided with one or more symmetry planes, it is possible to consider only the modes which respect the symmetry, whereby reducing the number and size of the obstacles which are needed. The horn 10 shown in the drawings is an example: by exploiting the vertical symmetry plane, the obstacles 101, 102 and the partition elements 103 are designed to reduce only the modes which respect such a symmetry.

[0038] According to a particularly advantageous embodiment, the obstacles 101,102 or partition elements 103 are relatively closer to said inlet opening 12 and relatively further away from said outlet opening 13. Ideally, the obstacles 101, 102 or the partition elements 103 should extend starting from the inlet opening 12 towards the inside of the flared conduit, but construction constraints may require a deviation from this ideal situation, so that it can be asserted that it is generally convenient to provide for the obstacles or the partition elements to start close, or rather as close as possible, to the inlet opening 12 or, if possible, at the inlet opening 12.

[0039] Preferably, the obstacles 101, 102 or the partition elements 103 have a maximum extension dimension smaller than 40% of the extension dimension of the main body 11 of the horn along the prevalent longitudinal extension axis A10, preferably lower than 30%, e.g. lower than 20%.

[0040] Preferably, the obstacles 101,102 are elements which protrude from inner walls of the flared conduit and, for example, are mechanically coupled to the main body 11 or made in one piece with such walls.

[0041] In the particular example shown, the obstacles 101, 102 on a plane perpendicular to the prevalent longitudinal extension axis A10 have a triangular section. Preferably, said obstacles 101,102 on a plane parallel to the prevalent longitudinal extension axis A10 of the horn 10 have a trapezoidal section.

[0042] Preferably, at least one of said obstacles, such as the obstacles 102, is arranged at angular positions of the flared conduit.

[0043] In the embodiment in figures 7 and 8 alternatively to the obstacles described above, partition elements 103 are included which divide the cross section of the conduit into two or more sub-sections in a limited portion. Preferably, said partition elements 103 comprise at least one tubular element 103 fixed inside the flared conduit. In the example shown in figures 7 and 8, the partition elements 103 are two tubular elements placed mutually side-by-side.

[0044] According to a preferred embodiment, the tubular elements 103 have walls, each of which is parallel to a respective wall portion 14-17 of the main body 11.

[0045] According to an embodiment, coherent with the example shown in figures 7 and 8, the horn 10 comprises spacer elements 104, 105 adapted and configured to distance the tubular elements 103 of the walls 14-17 of the main body 11.

[0046] According to a preferred embodiment, the acoustic transducer 1 comprises a transition 3, operatively interposed between the sound source 2 and the horn 10, and in particular between the sound source 2 and the inlet opening 12. According to a preferred embodiment, such a transition comprises a curved conduit. Such a transition 3 preferably comprises at least one circular inlet port 30 facing the sound source 2 and at least one quadrangular outlet port 31, rectangular 31 in the example, facing towards the inlet opening 12 of the horn 10. A curved conduit extends preferably between the circular inlet port 30 and the quadrangular outlet port 31. Since two sound sources 2 are provided in the example shown in the figures, the transition 3 comprises two circular inlet ports 30 and two curved conduits which converge into the quadrangular outlet port 31.

[0047] According to an advantageous embodiment, the transition 3 precedes the aforesaid obstacles 101, 102 or the aforesaid partition elements 103. In other words, the obstacles or the partition elements do not extend inside the transition 3 but only inside the horn 10.

[0048] According to an advantageous embodiment, the acoustic transducer 1 comprises a coupling flange 4 operatively interposed between the transition 3 and the horn 10. Preferably, the coupling flange 4 comprises a conduit which extends between two opposite openings 40, 41 which lay on two mutually inclined planes. For the mechanical coupling between the sound sources 2, the transition 3, the coupling flange 4 and the horn 10 the acoustic transducer 1 may comprise coupling elements, such as for example screws or bolts known to a person skilled in the art and for this reason not described in further detail.

[0049] As mentioned, the aforesaid acoustic transducer may be advantageously used in a sound broadcasting system installed in a road tunnel, including an array of transducers of the type described above installed along the course of the road tunnel on the upper wall of the road tunnel. For example, the acoustic transducers are mutually interposed at a distance comprised between 50 meters and 100 meters, e.g. equal to 75 meters. The acoustic broadcasting system comprises a plurality of amplifiers provided for supplying the sound sources of the acoustic speakers. Furthermore, the acoustic broadcasting system may comprise a microphone, or a plurality of microphones, to allow the system to detect the environmental noise in the tunnels and adjust the emitted sound power.

[0050] From the above, it is apparent that an acoustic transducer 1 of the type described above allows to fully achieve the set objects in terms of overcoming the drawbacks of the prior art.

[0051] [**0058**] Notwithstanding the principle of the invention, embodiments and details may be greatly varied with respect to those described and disclosed herein exclusively by way of non-limiting example without departing from the scope of the invention as defined in the appended claims.

Claims

1. An acoustic transducer (1) comprising:

   - a sound source (2) adapted to emit an acoustic radiation along a prevalent emission axis (A2);
   - a horn (10) operatively coupled to the sound source (2) and having an internally hollow main body (11) which extends between an inlet opening (12), adapted to receive said acoustic radiation, and an outlet opening (13) for the external broadcasting of said radiation, wherein the main body (11) has walls (14-17) which delimit a flared conduit having a variable section which allows the propagation of the acoustic radiation between the inlet opening (12) and the outlet opening (13), wherein the main body (11) extends along a prevalent longitudinal extension axis (A10) which is misaligned with respect to the prevalent emission axis (A2) of the sound source (2);

   characterized in that
   the horn (10) comprises, inside the flared conduit, one or more obstacles (101,102) or partition elements (103) which locally narrow the section of the

flared body in at least two transverse directions (D11-D12) with respect to the prevalent longitudinal extension axis (A10).

2. An acoustic transducer (1) according to claim 1, wherein said acoustic radiation has a main mode and superior modes, wherein said obstacles (101,102) or said partition elements (103) are such as to increase the cutoff frequency of the superior modes in the horn (10).

3. An acoustic transducer (1) according to claim 1 or 2, wherein said obstacles (101,102) or partition elements (103) are relatively closer to said inlet opening (12) and relatively further from said outlet opening (13).

4. An acoustic transducer (1) according to any one of the preceding claims, wherein said obstacles (101,102) are elements which protrude from inner walls of the flared conduit.

5. An acoustic transducer (1) according to claim 4, wherein said obstacles (101,102) have a triangular section on a plane perpendicular to said prevalent longitudinal extension axis (A10) and preferably have a trapezoidal section on a plane parallel to said prevalent longitudinal extension axis (A10).

6. An acoustic transducer (1) according to claims 4 or 5, wherein one or more of said obstacles (101, 102) are arranged at angular portions of the flared conduit.

7. An acoustic transducer (1) according to any one of the claims from 1 to 3, wherein said partition elements (103) divide the section of the conduit into two or more sub-sections, in a limited portion of the flared conduit.

8. An acoustic transducer (1) according to claim 7, wherein said partition elements (103) comprise at least one tubular element fixed inside the flared conduit.

9. An acoustic transducer (1) according to claim 8, wherein said partition elements (103) are two tubular elements placed side-by-side.

10. An acoustic transducer (1) according to any one of the preceding claims, wherein said flared conduit is delimited by two mutually opposite walls (14,16) having a mutually different shape, wherein one of said walls (16) is preferably flat and the other of said walls (14) is at least partially curved.

11. An acoustic transducer (1) according to claim 10, wherein said flared conduit is delimited by two further, mutually opposite walls (15,17) having the same shape.

12. An acoustic transducer (1) according to any one of the preceding claims, wherein said outlet opening (13) is quadrangular in shape.

13. An acoustic transducer (1) according to any one of the preceding claims, wherein said obstacles (101, 102) or partition elements (103) have a maximum extension dimension which less than 40% of the extension dimension of the main body (11) of the horn along said prevalent longitudinal extension axis (A10).

14. An acoustic transducer (1) according to any one of the preceding claims, wherein the horn (10) comprises at least two of said obstacles (101,102) or at least two of said partition elements (103).

15. An acoustic transducer according to any one of the preceding claims, comprising a transition (3) operatively interposed between the sound source (2) and the horn (10), and in particular between the sound source (2) and the inlet opening (12), and wherein such a transition comprises a curved conduit.

16. A sound and/or voice message broadcasting system in a road tunnel, comprising an array of acoustic transducers (1) according to any one of the preceding claims, installed on an inner wall of the road tunnel.

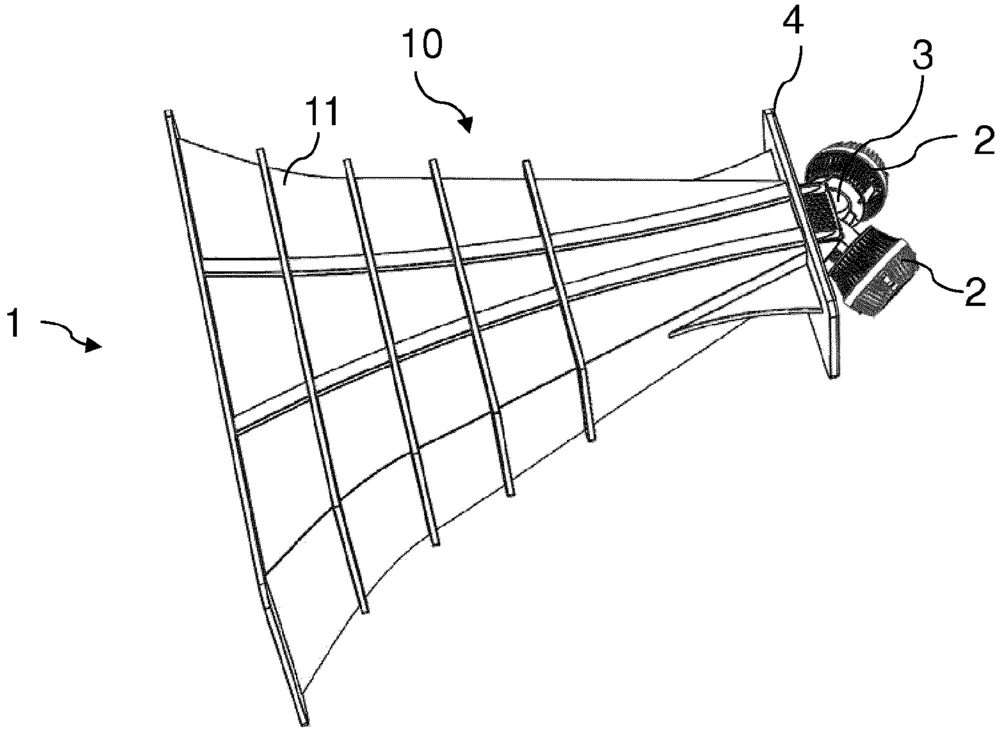


FIG. 1

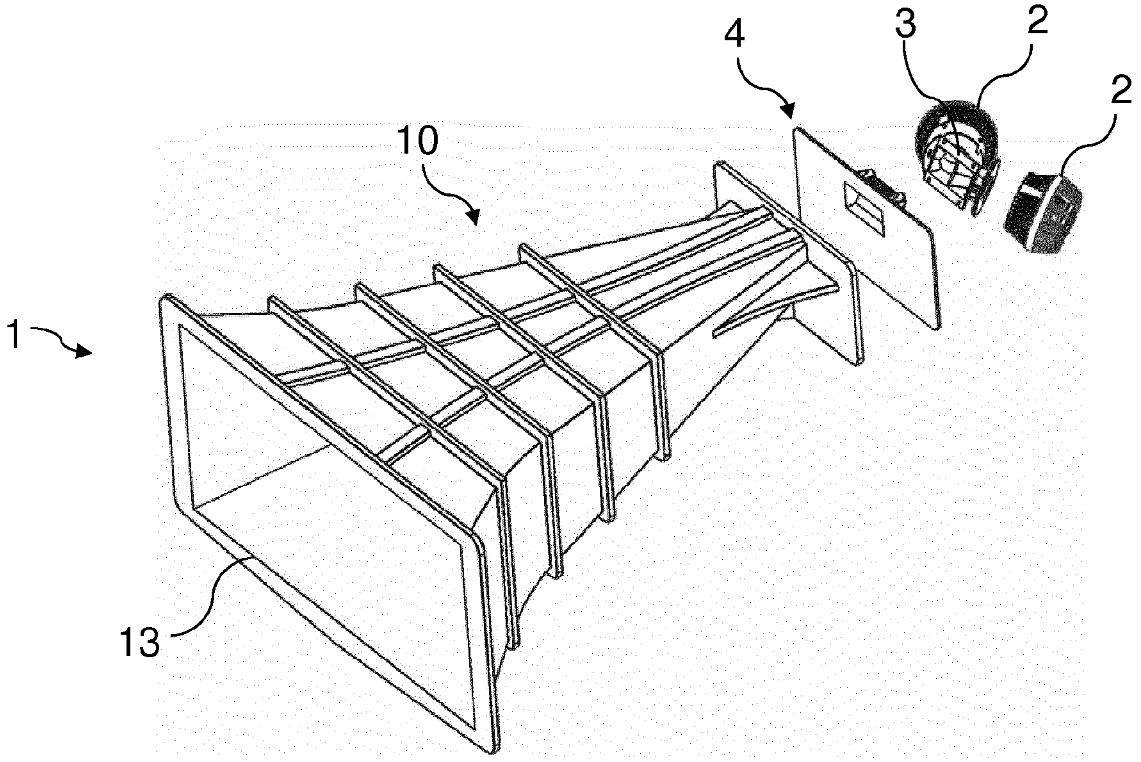
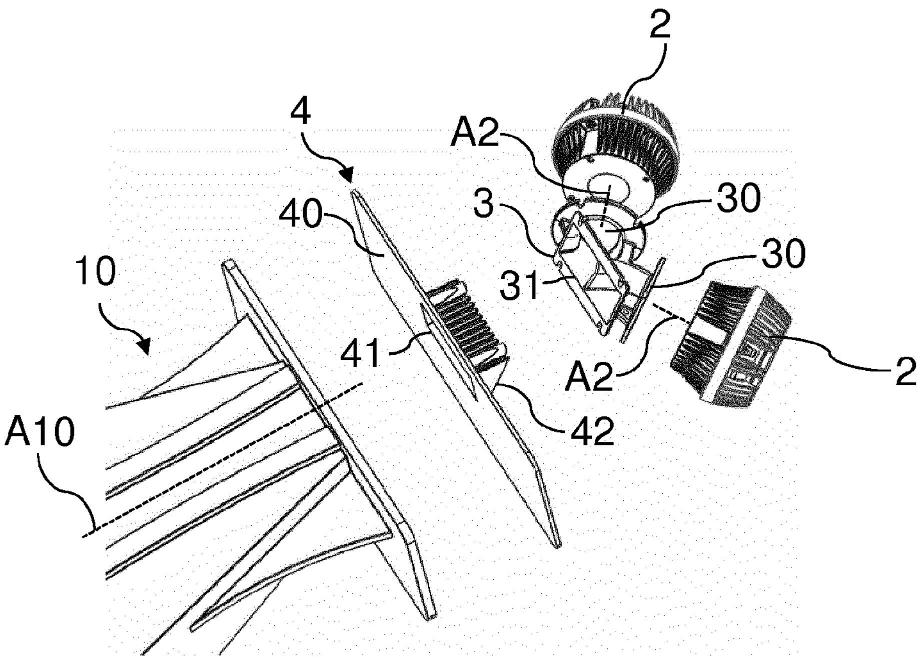


FIG. 2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A2
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41
A2
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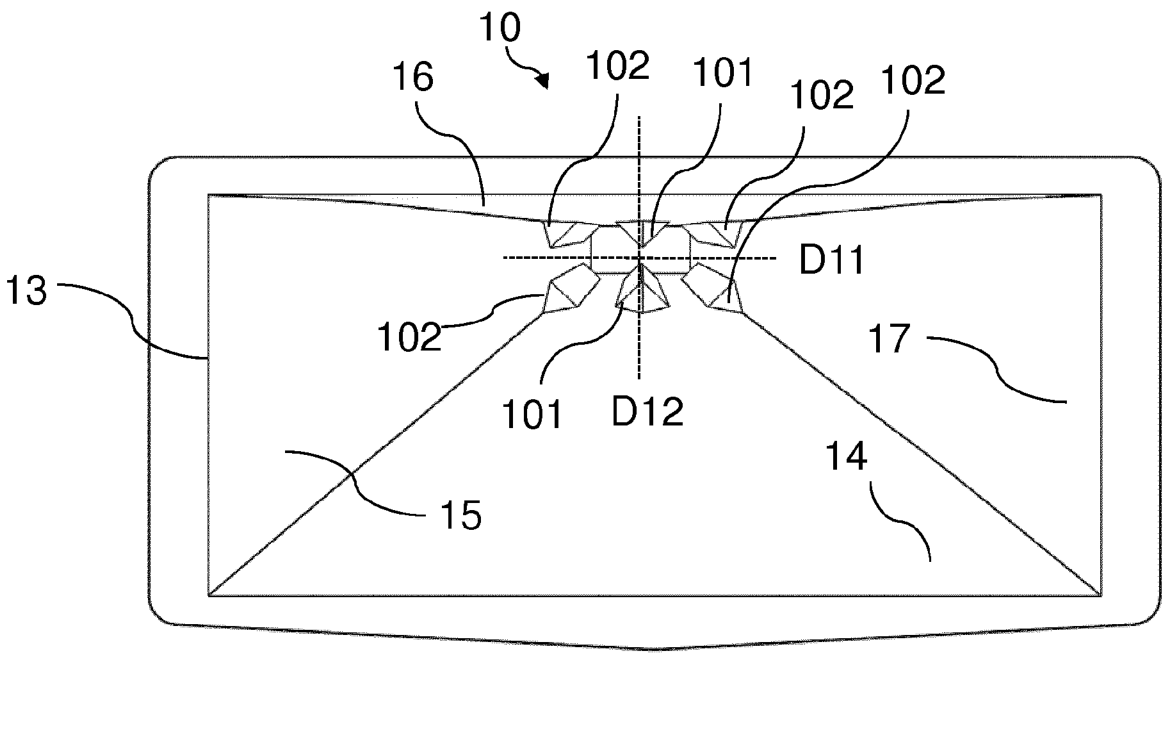
A10

FIG. 3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102
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D11
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101
D12
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FIG. 4

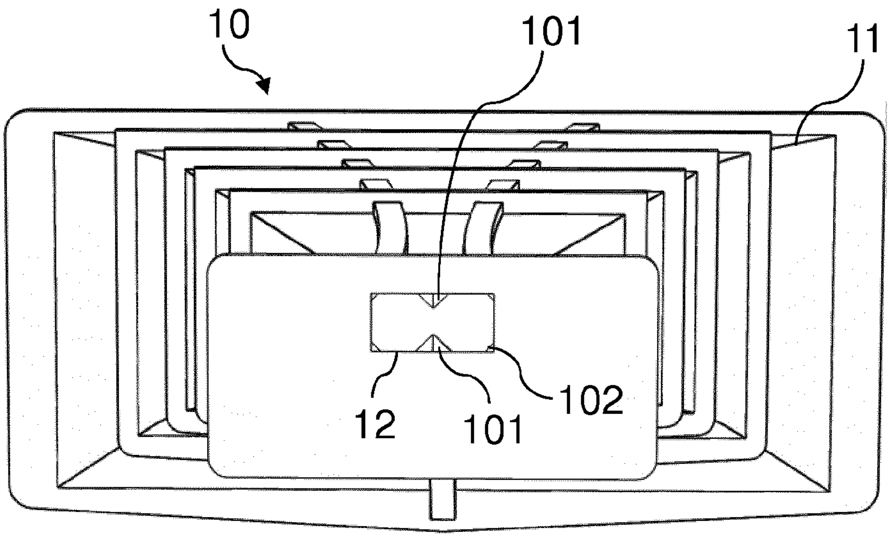

FIG. 5

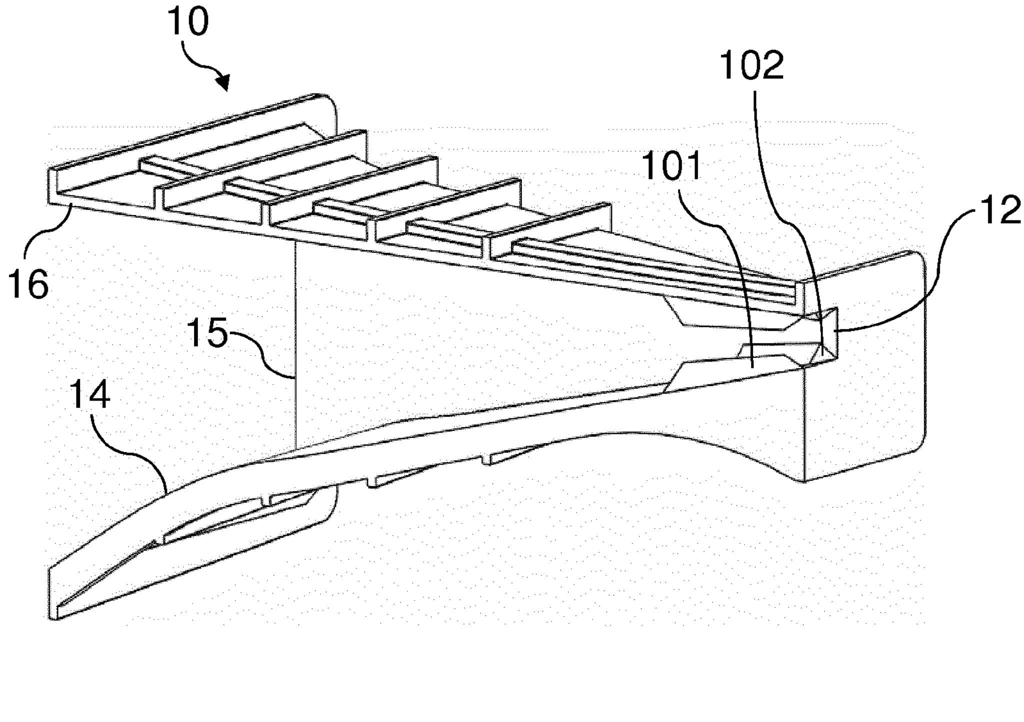

FIG. 6

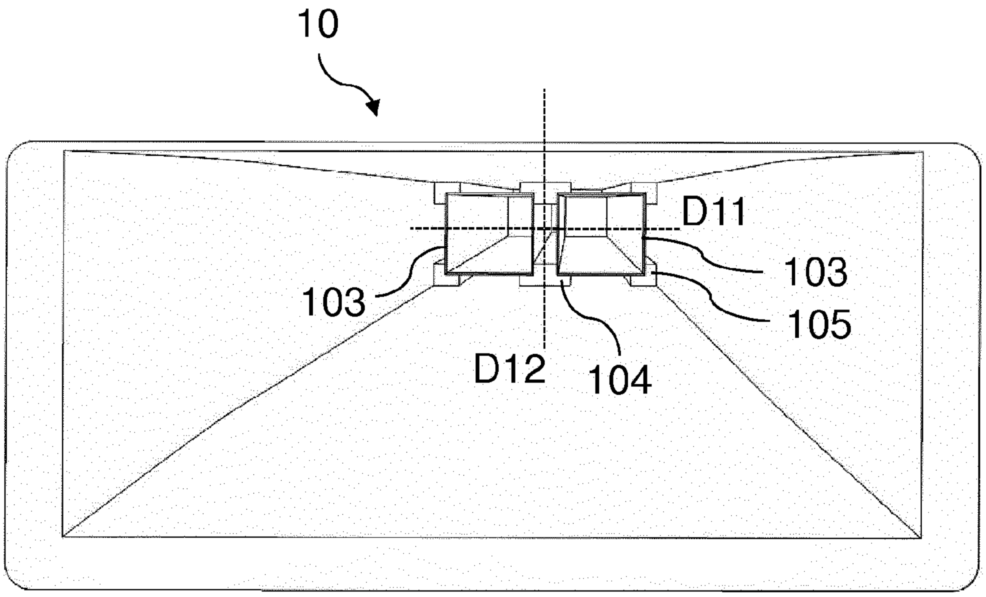

FIG. 7

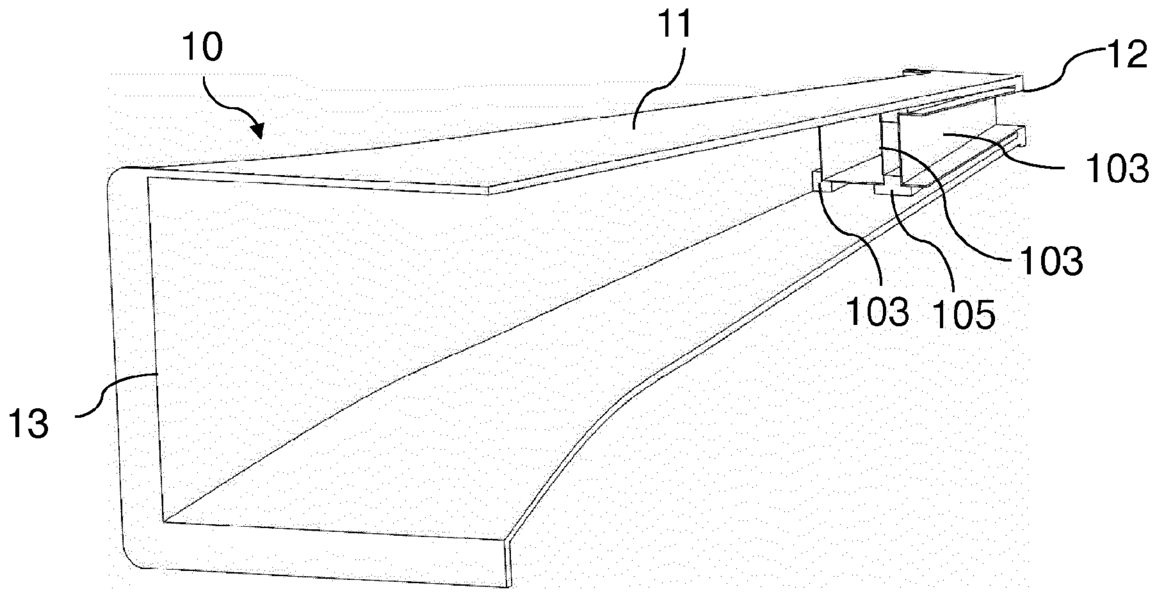

FIG. 8

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EUROPEAN SEARCH REPORT

Application Number
EP 17 20 4722

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	US 6 658 128 B1 (YOSHIOKA TSUTOMU [JP] ET AL) 2 December 2003 (2003-12-02) * column 1, lines 30-45 * * column 4, line 66 - column 6, line 40; figures 1, 2(a)-2(e) * * figure 9 *	1,3-6, 12,13	INV. G10K11/02 H04R1/30 H04R1/28
Y	WO 03/069952 A1 (DURAN AUDIO B V [NL]; DE VRIES GERARD HENDRIK JOSEPH [NL]) 21 August 2003 (2003-08-21) * page 1, lines 4-7 * * page 3, lines 8-9; figure 3a * * page 3, lines 15-16; figure 3b * * figure 4 * * page 4, line 23 * * page 5, lines 24-26 * * page 6, lines 4-7 *	1-3,7-16	
Y	US 2 203 875 A (OLSON HARRY F) 11 June 1940 (1940-06-11) * page 2, left-hand column, line 52 - right-hand column, line 30 * * figures 2-4 *	1-3,7-16	TECHNICAL FIELDS SEARCHED (IPC) G10K H04R
A,D	US 8 995 700 B2 (D & B AUDIOTECHNIK GMBH [DE]) 31 March 2015 (2015-03-31) * column 6, lines 9-35; figure 2 *	15	
A	EP 1 927 978 A1 (B & C SPEAKERS S P A [IT]) 4 June 2008 (2008-06-04) * abstract *	1	

1

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	3 April 2018	Torcal Serrano, C

CATEGORY OF CITED DOCUMENTS

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EPO FORM 1503 03.82 (P04C01)

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This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

03-04-2018

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 6658128 B1	02-12-2003	JP 3732007 B2	05-01-2006
		JP H11313387 A	09-11-1999
		US 6658128 B1	02-12-2003
WO 03069952 A1	21-08-2003	AT 518379 T	15-08-2011
		AU 2003206435 A1	04-09-2003
		EP 1474951 A1	10-11-2004
		ES 2370391 T3	15-12-2011
		JP 4320440 B2	26-08-2009
		JP 2005518171 A	16-06-2005
		NL 1019961 C2	15-08-2003
		US 2005127783 A1	16-06-2005
		WO 03069952 A1	21-08-2003
US 2203875 A	11-06-1940	NONE	
US 8995700 B2	31-03-2015	CN 103634722 A	12-03-2014
		DE 102012107645 A1	27-02-2014
		GB 2506978 A	16-04-2014
		US 2014056458 A1	27-02-2014
EP 1927978 A1	04-06-2008	AT 424021 T	15-03-2009
		CA 2610944 A1	30-05-2008
		CN 101192403 A	04-06-2008
		EP 1927978 A1	04-06-2008
		ES 2323156 T3	07-07-2009
		US 2008128199 A1	05-06-2008

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- US 2135610 A **[0004] [0019]**
- US 8995700 B2 **[0004]**