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(54) **Loudspeaker horn**

(57) A horn for a loudspeaker comprising an entrance, an output, a first passage junction that divides acoustic energy received at the entrance into at least first and second passages and a second passage junction that divides one of said first and second passages into at least third and fourth passages, in which the passages derived from the entrance open into the output.

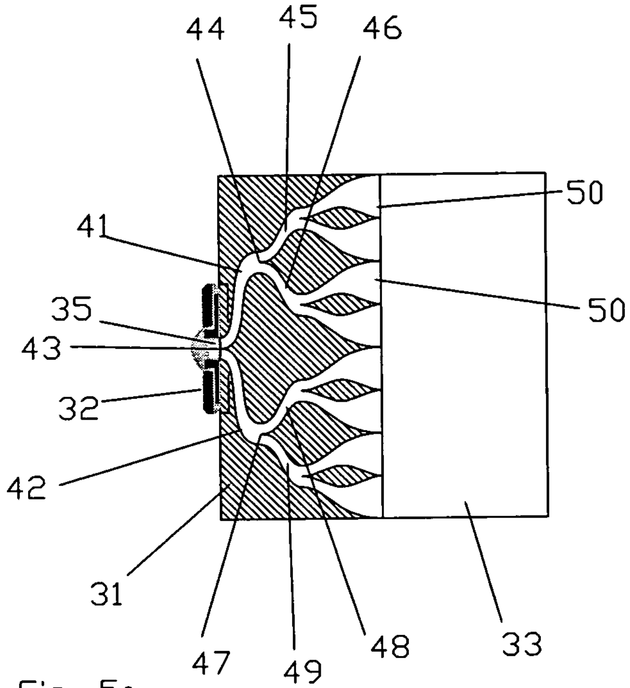

Fig. 5a

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Description

[0001] The present invention relates to a horn for use with a loudspeaker and, in particular, a horn to couple a compression driver to a mouth having a high aspect ratio.

[0002] In the field of high power sound reproduction, the transduction of electrical power to acoustic power is frequently achieved by the use of a compression driver. A compression driver is arranged such that the piston area is greater than the throat immediately adjacent to it. It should be appreciated, however, that the compression driver may further include a tapered duct immediately following the throat. The compression driver is arranged in order to effect an optimum match of impedances and hence maximise the power transfer. The compression driver is typically attached to a waveguide of gradually increasing cross-sectional area, namely a horn.

[0003] An important aspect of the horn performance is the coverage pattern of the wavefront which emerges. The aim is to deliver a predictable level of sound to all members of, for example, a concert audience. Frequently, this pattern needs to be quite wide while being rather narrow in the vertical direction.

[0004] A common way of obtaining such a pattern is through the use of a horn having a slot-shaped output, namely an output that is rectangular in cross-section and substantially longer than it is wide, connected to a flared manifold. As long as the width of the slot is smaller than the wavelength of a sound being transmitted, diffraction effects mean that the wave front fills the manifold, resulting in a sound field with an angle approximately identical to that of the manifold.

[0005] Figures 1A and 1B depict, respectively, a vertical cross-section and a cross-section in plan view of such a conventional loudspeaker arrangement. In particular, the loudspeaker 1 includes a compression driver 2 connected to a horn 3 that gradually increases in height, resulting in a slot-shaped output 3A. The slot-shaped output 3A is connected to a flared manifold 4. The angle 5 of the flared manifold 4 provides a wide sound field in the horizontal direction, providing the required coverage of an audience. As shown, the coverage angle 6 in the vertical direction, determined by the wall angle of the horn 3, is significantly smaller than the horizontal coverage angle 5. It should be appreciated that, in this description, the references to the horizontal and vertical directions are for clarity and refer to a loudspeaker being used in its conventional orientation. However, the loudspeaker is not limited to use in this orientation.

[0006] As shown in Figure 2A, a loudspeaker arrangement as depicted in Figures 1A and 1B may be used to provide adequate sound coverage to an audience. However, as depicted in Figure 2B, for a deeper audience area, it may be necessary to use a number of loudspeakers together in order to provide the required level of sound across the audience area. In order to combine a number of loudspeakers to form a loudspeaker unit, it is necessary that the individual components add together to form a single wavefront without interference. Accordingly, it should be arranged that the wavefront emerges from each of the loudspeakers with a centre of curvature that is coincident with the centre of the array. However, as depicted in Figure 3, this is not possible when using a plurality of loudspeakers of the type described above and shown in Figures 1A and 1B. Figure 3 depicts, in vertical cross-sections two loudspeakers 10,11 to be used together. However, as shown, the presence of the respective compression drivers 12,13 results in the respective horns 14,15 being disposed at an angle that results in the interference of the respective wave fronts 16,17 propagating from the two loudspeakers 10,11. This problem may not be overcome by increasing the separation of the horns and manifolds at the end away from the compression drivers 12,13 because it is important that the gap between these be minimised because this gap may also give rise to interference.

[0007] It is an object, therefore, to provide a horn which can be connected to the output of a compression driver and has a slot-shaped output, for example a mouth having a small width compared to the wavelength, that can be connected, for example, to a flared manifold. Preferably, the horn should provide an output wavefront with a small degree of curvature in order to facilitate the provision of the horn adjacent to the horn of another loudspeaker.

[0008] Figures 4A and 4B schematically depict, in vertical cross-section and in a cross-section plan view, respectively, a loudspeaker previously considered in relation to this problem.

[0009] As shown, the loudspeaker 20 includes a compression driver 21, a horn 22 and a flared manifold 23. As shown, the horn 22 includes a plurality of hornlets 25 that each connect the output 26 of the compression driver to the slot-shaped entrance 27 of the flared manifold 23.

[0010] However, this arrangement is difficult to manufacture. In particular, the output 26 of the compression driver is relatively small compared to the number of hornlets 25 necessary to connect the compression driver to the slot-shaped entrance 27 of the flared manifold 23. Consequently, the entrance of each of the hornlets 25 will be very small. A consequence of this is that the width of the walls within the horn 22 that separate the entrances of the hornlets 25 will need to be extremely narrow and are therefore difficult to manufacture.

[0011] It is an object of the present invention to provide an improved horn for a loudspeaker.

[0012] According to the present invention, there is provided a horn for use in a loudspeaker, comprising
an entrance;
an output;
a first passage junction that divides acoustic energy received at the entrance into at least first and second passages; and
a second passage junction that divides one of said first and second passages into at least third and fourth pas-

sages;
wherein the passages derived from the entrance open into the output and the passages are configured to provide the pathlengths for acoustic energy travelling from the entrance to the output that are necessary to provide a required shape of wavefront at the output.

[0013] Accordingly, by providing successive sub-divisions of the passages within the horn, it is possible to provide a plurality of passages that open into an output without requiring a large number of passages to connect directly to the entrance. Consequently, the requirement to keep the thickness of the wall between the passages as small as possible is avoided and manufacture of the horn is simplified.

[0014] Preferably, the passages derived from the entrance of the horn successively divide to provide a plurality of passages that open into the output. The plurality of passages may be arranged to open into the output in a single row, for example providing the aspect ratio of a conventional slot-shaped output that may be connected to a flared manifold.

[0015] Advantageously, each of the passage junctions within the horn divides a respective passage into only two further passages. Accordingly, it may be ensured that the signal is divided evenly between passages at each junction for all frequencies.

[0016] For convenience, only a single passage within the horn may be connected to the entrance of the horn. Alternatively, however, the first division into two or more passages within the horn may occur at the entrance.

[0017] Preferably, the horn is configured such that acoustic energy that travels from the entrance to the output of the horn passes through the same number of passage junctions, regardless of its route through the horn. Consequently, provided that each of the passage junctions divides a passage into the same number of subsequent passages, for example two, then the acoustic energy is divided equally between each of the passages that open into the output, providing an even energy distribution across the output of the horn.

[0018] Furthermore, the passages within the horn may be configured such that the pathlength for acoustic energy travelling from the entrance to the output is the same, regardless of from which passage it is provided into the output. Consequently, the wavefront output from the horn may be arranged to have little or no curvature, facilitating the placement of a plurality of loudspeakers, each including the horn, adjacent one another.

[0019] Preferably, the passages are configured to be substantially straight at the point at which they open into a passage junction. Accordingly, a frequency dependent imbalance of the sound energy in the two subsequent passages, caused by a frequency dependant variation of pressure distribution across the width of a passage in the vicinity of a bend, may be minimised. Preferably, the passage is substantially straight for at least a distance prior to the passage junction that is equivalent to the wavelength of the highest frequency of the sounds to be propagated through the horn.

[0020] The arrangement of the sub-section divisions of the passages may be oriented such that all of the passages lie substantially within a plane. Such an arrangement may facilitate the manufacture of the horn.

[0021] In any case, the horn may be formed from two portions that are formed separately and are then connected together. In a particular arrangement, each of the passages within the horn is defined by a portion formed within one part of the horn and a portion formed within the other part of the horn. Consequently, each of the parts of the horn are simple to manufacture and may, for example, be formed by injection moulding.

[0022] The horn may be connected to a compression driver and/or a flared manifold in order to form a loudspeaker. Furthermore, such a loudspeaker may be combined with other such loudspeakers in order to form a convenient loudspeaker unit.

[0023] The invention will now be described by way of non-limiting examples with reference to the accompanying drawings, in which:

Figures 1A and 1B depict a conventional loudspeaker;
Figures 2A and 2B depict the required projection of sound to an audience;
Figures 3 depicts a difficulty of combining loudspeakers of the type depicted in Figures 1A and 1B;
Figures 4A and 4B depict an alternative loudspeaker arrangement;
Figures 5A and 5B depict a loudspeaker incorporating a horn according to the present invention; and
Figure 6A and 6B depict a loudspeaker having an alternative horn according to the present invention.

[0024] Figures 5A and 5B show in vertical cross-section and cross-section plan view, respectively, a loudspeaker 30 including a horn 31 according to the present invention. As shown, the loudspeaker 30 also includes a compression driver 32 connected to the horn 31 and a flared manifold 33 having a slot-shaped entrance 34 connected to the output of the horn 31.

[0025] As shown, the horn 31 includes a plurality of passages that are provided to transfer acoustic energy received at the entrance 35 of the horn 31 to the slot-shaped entrance 34 of the flared manifold 33. In particular, the horn 31 includes first and second passages 41,42 leading from a passage junction 43 arranged at the entrance 35 to the horn 31. The first passage 41 leads to a second passage junction 44 that divides the first passage in to third and fourth passages 45,46. In the arrangement depicted in Figures 5A and 5B, the second passage 42 is also divided at a passage junction 47 into further passages 48,49. Furthermore, each of the passages 45,46,48,49 is further subdivided by a respective passage junction into two further passages. The resulting passages 50 open into the entrance 34 of the flared manifold 33.

[0026] It should be appreciated that, although the arrangement depicted in Figures 5A and 5B is an arrangement according to the present invention, the present invention may be effected by variations of the horn 31 depicted in Figures 5A and 5B.

[0027] In particular, although in the arrangement depicted in Figures 5A and 5B, the passages in the horn 31 divide into two at three stages, providing eight passages that open into the output, this need not be the case. Any suitable number of stages of subdivision may be provided, allowing, for example, the provision of 4, 8, 16 or 32 passages opening into the output.

[0028] Alternatively or additionally, although in the arrangement depicted in Figures 5A and 5B each of the passages is divided the same number of times such that the acoustic energy output from each of the passages 50 into the entrance 34 of the flared manifold 33 has passed through the same number of passage junctions, this need not be the case.

[0029] Alternatively or additionally, although in the arrangement depicted in Figures 5A and 5B the first passage junction 43 is arranged at the entrance 35 to the horn 31, this need not be the case. Instead, a passage may be provided to direct all of the acoustic energy received at the entrance 35 of the horn 31 to the first passage junction which may therefore be set apart from the entrance 35 to the horn 31.

[0030] Alternatively or additionally, although in the arrangement depicted in Figures 5A and 5B each of the passage junctions divide an associated passage into two further passages, this need not be the case. For example, one or more of the passage junctions may divide a passage into three or more passages.

[0031] Accordingly, any desired number of passages may be arranged to open into the entrance 34 of the flared manifold 33.

[0032] Alternatively or additionally, although the arrangement depicted in Figure 5A and 5B is configured such that the pathlength for acoustic energy propagating from the entrance 35 of the horn 31 to the entrance 34 of the flared manifold 33 is the same regardless of which passage 50 it exits the horn 31, this need not be the case. In particular, the pathlength may be adjusted in order to provide any required shape of wavefront at the entrance 34 to the flared manifold 33.

[0033] The ability to configure the horn 31 to provide a required shape of wavefront at the entrance 34 to the flared manifold 33 is facilitated by the arrangement of the horn. In particular, the passages within the horn 31 are not formed by separating them from each other by a simple dividing wall (which may, for example, have a uniform thickness along its length). Accordingly, the choice of the configuration of one passage is largely independent from the choice of the configuration of an adjacent passage. As a result, it is possible to select relatively complicated shapes for each of the passages, which, in turn, permits the independent control for each of the passages of the pathlength for acoustic energy passing down the passages.

[0034] For example, as shown in Figure 5A one may arrange a required acoustic pathlength for each of the passages by selecting the curvature of the individual passages. In particular, by selecting the arrangement of a passage from the entrance 35 of the horn 31 to the entrance 34 of the flared manifold 33 such that, tracing the passage from one end to the other, the centre of curvature passes from one side of the passage to the other at least twice, namely includes two inflection points, introducing a meander or "wiggle" into the shape of the passage, a greater acoustic pathlength may be provided for a given volume of space available than if, for example, the passage were straight. By selecting appropriate variations of such a shape for each of the passages, it is possible to provide the appropriate acoustic pathlength for each of the passages such that a required shape of wavefront at the entrance 34 to the flared manifold 33 is provided. It will be appreciated that alternative ways of shaping the passages in order to control the acoustic pathlength may alternatively or additionally be used.

[0035] Alternatively or additionally, although the horn 31 is depicted in Figures 5A and 5B for use with a compression driver 32 and a flared manifold 33, the horn 31 need not be used with such components and, although horn 31 is depicted in Figures 5A and 5B as having a slot-shaped output, this need not be the case. For example, each of the passages may include a flared portion such that a flared manifold is not required to be connected to the output or that a smaller flared manifold may be used. It should also be appreciated that, in situations in which a flared manifold is required, it may be integrally formed with the horn.

[0036] Alternatively or additionally, although the horn depicted in Figures 5A and 5B is configured such that all of the passages within the horn 31 are arranged to lie substantially within a single plane, this need not be the case. In particular, in order to adjust the pathlength for some of the passages, the passages may deviate from the plane. Consequently, instead of lying within a plane corresponding to the cross-section depicted in Figure 5A, for example, a part of one or more of the passages may lie above or below that plane.

[0037] Figures 6A and 6B depict in a vertical cross-section and in a cross-section plan view, respectively, a loudspeaker 60 that is a variant of the arrangement depicted in the Figures 5A and 5B. In particular, in the arrangement depicted in Figures 6A and 6B, the horn 61 is arranged such that the passage junctions 62 are arranged at a location within a respective passage to be divided at which the passage is substantially straight and, preferably, the passage junction is arranged at a location such that the passage is straight immediately prior to the passage junction for a distance that is at least the wavelength of the highest frequency sound for which the horn 61 is intended to transmit. For example the highest frequency for which the horn is intended to be used may be 20kHz, in which case the passages may be arranged to be straight for at least 17mm prior to a passage junction.

[0038] It should be appreciated that, although it may be preferable for this condition to be met for all passage junctions this need not be the case. It should further be appreciated that the variations discussed above in relation to the arrangement depicted in Figures 5A and 5B also apply to the arrangement depicted in Figures 6A and 6B.

[0039] The horn of the present invention may be composed of a first section and a second section that are formed separately and combined together. For example, the first section and the second section of horns such as those depicted in Figures 5A, 5B, 6A, 6B may be divided by a plane parallel to the plane of the cross-section depicted in Figures 5A and 6A. Accordingly, each of the passages within the horn 31, 61 is defined by a portion of the first section of the horn and a portion of the second section of the horn. Accordingly, it is relatively straightforward to form each of the two sections of the horn 31,61, for example by injection moulding.

[0040] Furthermore, for horns such as those depicted in Figures 5A, 5B, 6A, 6B, namely horns that are symmetrical about a line passing through the entrance to the horn 31,61, the horn may be formed from two identical sections that are joined together.

[0041] It should be appreciated that, in an arrangement in which the passages within the horn 31,61, do not lie within a single plane, the division between the two sections from which the horn is formed will not lie within a plane, but may be arranged to correspond substantially to the centre-line of each of the passages such that each passage is defined by a portion of the first section of the horn and a portion of the second section of the horn, thus enabling both parts of the horn to be easily manufactured by, for example, injection moulding.

Claims

1. A horn for use in a loudspeaker, comprising
an entrance;
an output;
a first passage junction that divides acoustic energy received at the entrance into at least first and second passages; and
a second passage junction that divides one of said first and second passages into at least third and fourth passages;
wherein the passages derived from the entrance open into the output and the passages are configured to provide the pathlengths for acoustic energy travelling from the entrance to the output that are necessary to provide a required shape of wavefront at the output.

2. A horn according to claim 1, wherein at least one of said passages is curved such that, passing from the entrance to the opening, the centre of curvature passes from one side of the passage to the other at least twice.

3. A horn according to claim 1 or 2, wherein the openings of the passages opening into the output are arranged to form a single row of openings.

4. A horn according to claim 1, 2 or 3, wherein a passage directs substantially all the acoustic energy received at the entrance to the first passage junction.

5. A horn according to claim 1, 2 or 3, wherein said first passage junction is arranged at the entrance of said horn.

6. A horn according to any one of the preceding claims, wherein each passage junction within the horn divides the passage with which it is associated into two passages.

7. A horn according to any one of the preceding claims, wherein the horn is configured such that any acoustic energy travelling from the entrance to the output passes through the same number of passage junctions, regardless of from which passage it is emitted into the output.

8. A horn according to any one of the preceding claims, wherein the horn is configured such that the pathlength for any acoustic energy travelling from the entrance to the output is the same, regardless of from which passage it is emitted into the output.

9. A horn according to any one of the preceding claims, wherein each of the passages is substantially straight at a point at which it leads into a passage junction; and, preferably, each of the passages is substantially straight where it leads into a passage junction for at least a distance that is the wavelength of the highest frequency of sound with which the horn is intended to be used.

10. A horn according to any one of the preceding claims, wherein the horn is formed from first and second horn sections that are separately formed and joined together; and each passage within the horn is defined by the combination of a respective portion of the first horn section and a respective portion of the second horn section.

11. A horn according to any one of the preceding claims, wherein each of the passage junctions is configured such that lines, corresponding to the centres of the passage leading to the passage junction and the passages that it divides into, lie within and define a plane of orientation of the passage junction; and the respective planes of orientation of all of the passage junctions are substantially parallel.

12. A horn according to any one of the preceding claims, wherein at least one of the passages includes a section that is flared.

13. A loudspeaker comprising a compression driver unit and a horn according to any one of the preceding claims;
wherein the output of the compression driver is coupled to the entrance of the horn.

14. A loudspeaker according to claim 13, further comprising a flared manifold, coupled to the output of the horn.

15. A loudspeaker unit, comprising a plurality of loudspeakers according to claim 13 or 14, arranged adjacent to one another.

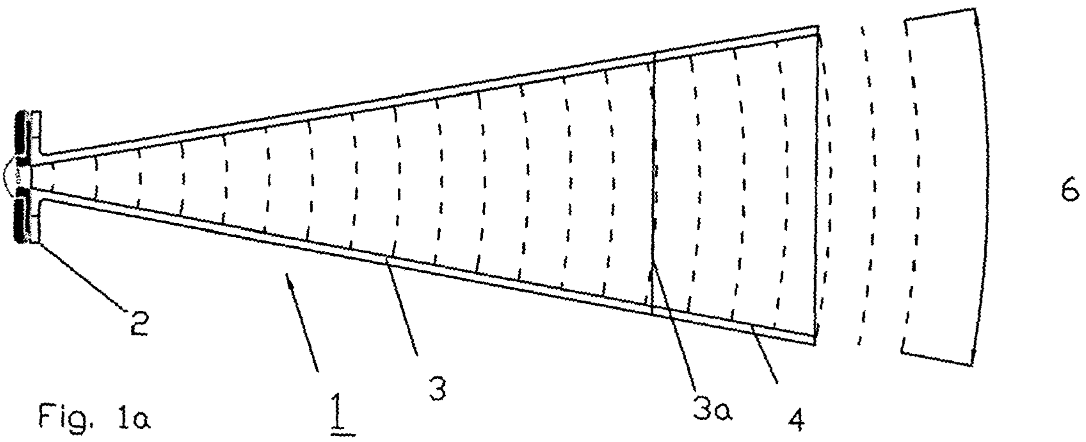

Fig. 1a

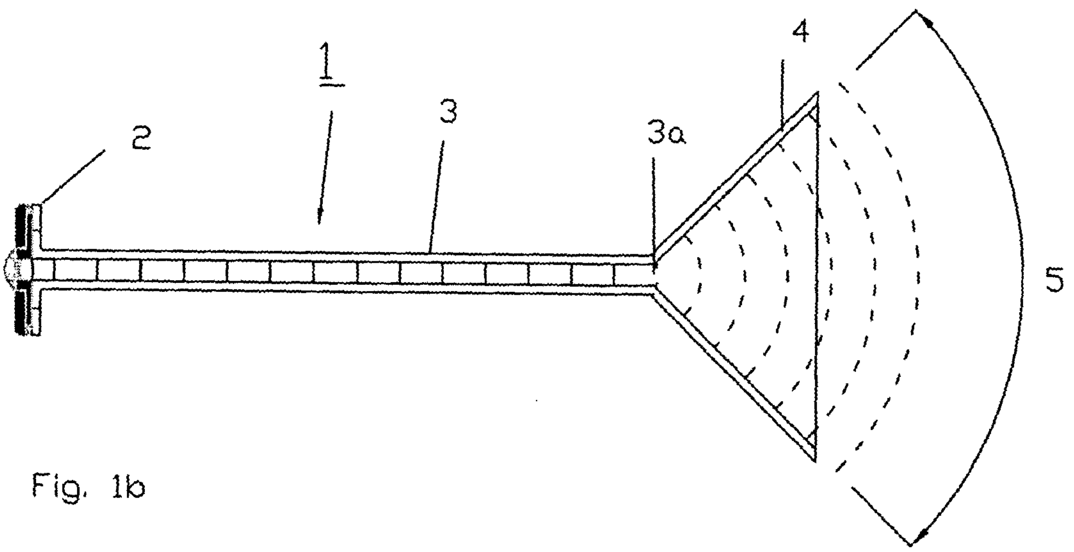

Fig. 1b

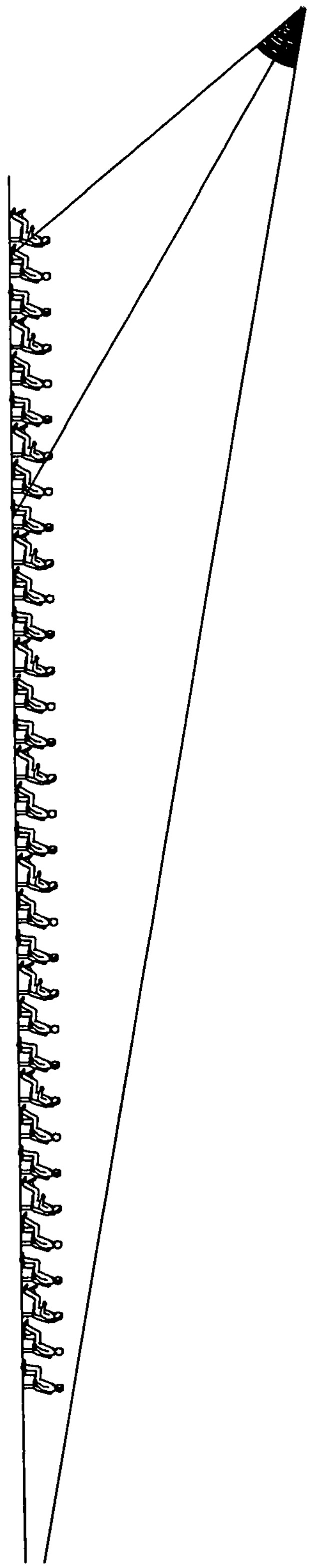

Fig. 2a

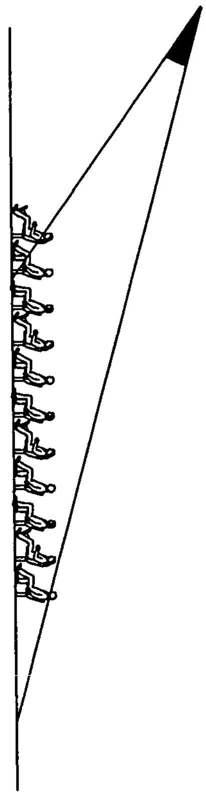

Fig. 2b

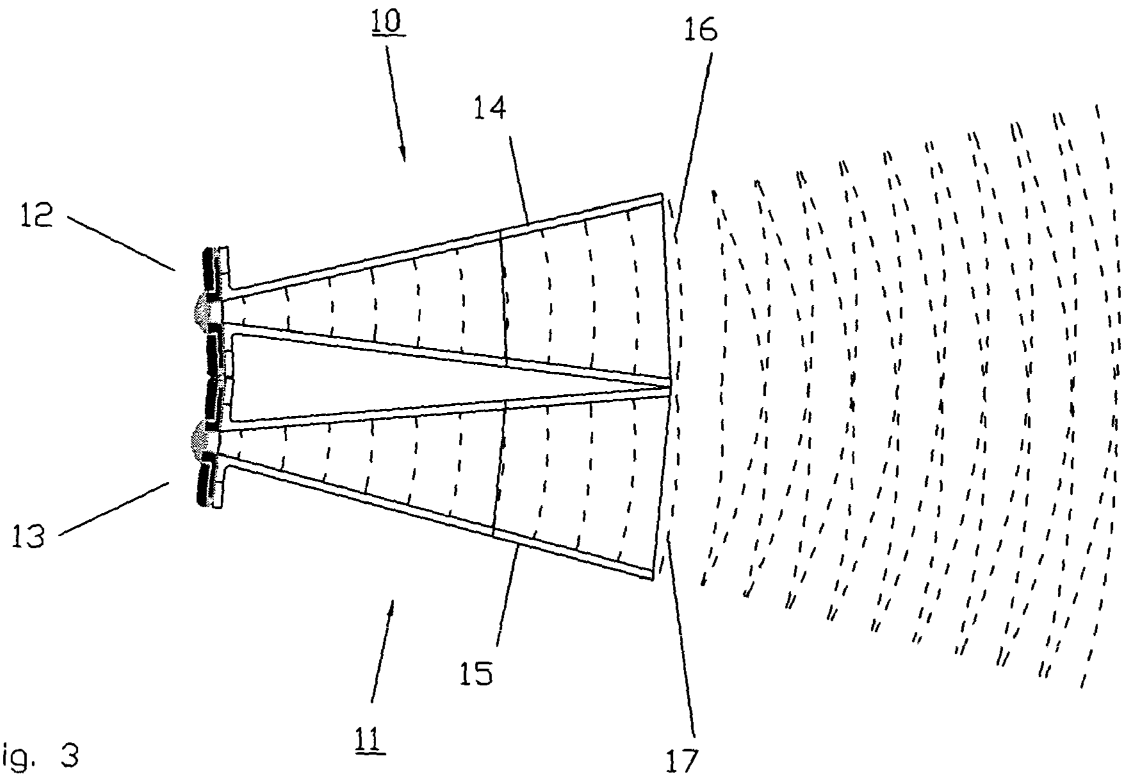

Fig. 3

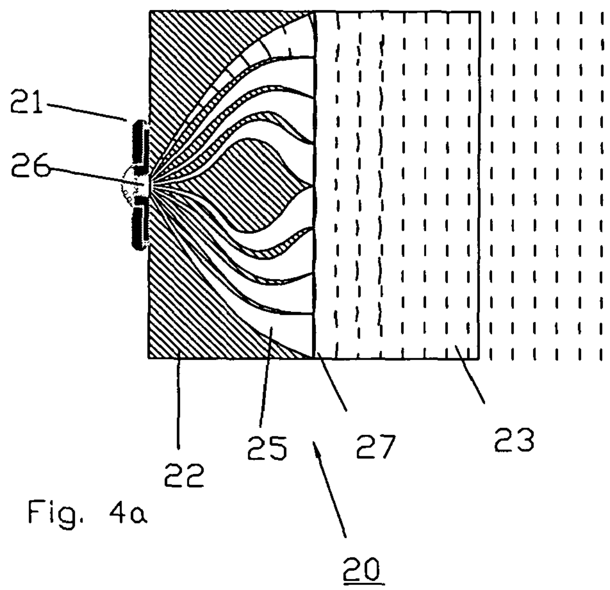

Fig. 4a

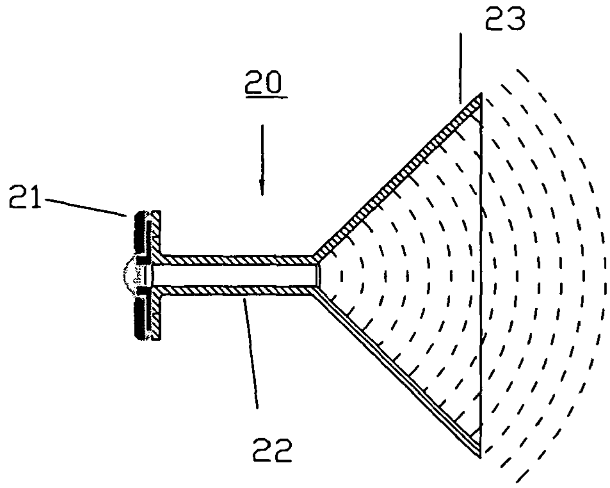

Fig. 4b

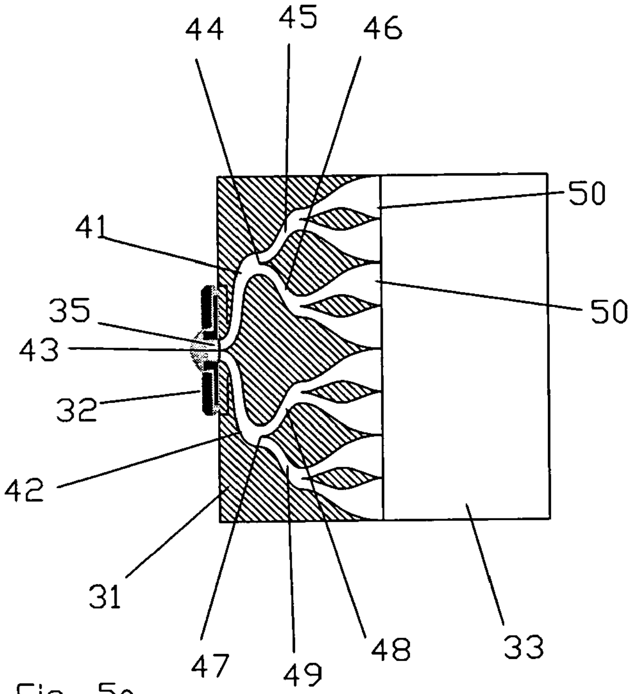

Fig. 5a

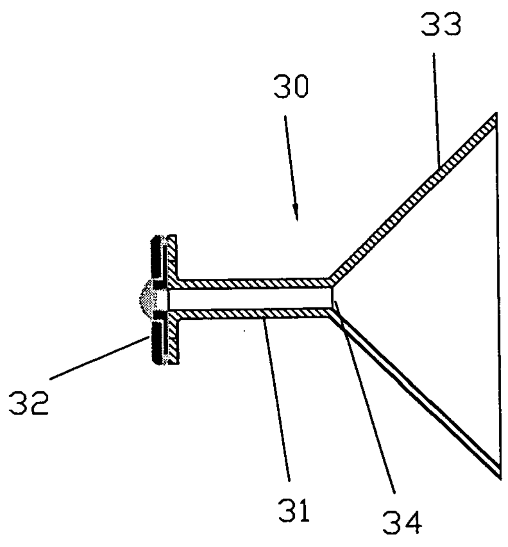

Fig. 5b

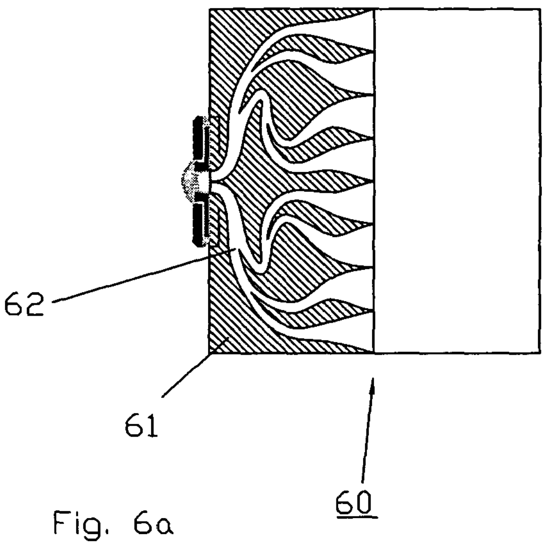

Fig. 6a

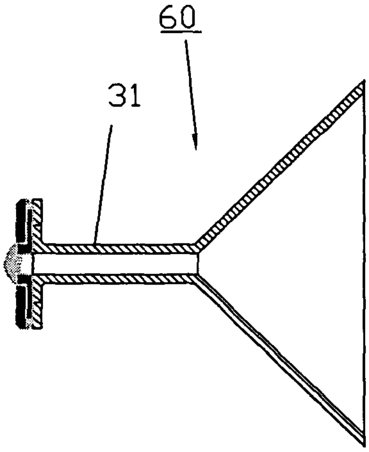

Fig. 6b

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 08 25 1943

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 2007/080019 A1 (KUBOTA HIROSHI [JP]) 12 April 2007 (2007-04-12) * paragraphs [0001], [0004] - [0025], [0041] - [0072], [0124] - [0130]; figures 1-6,10-12 * -----	1-15	INV. H04R1/34
X	GB 297 151 A (BELL TELEPHONE LABOR INC) 17 September 1928 (1928-09-17) * the whole document * -----	1-14	

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	4 September 2008	Navarri, Massimo

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CATEGORY OF CITED DOCUMENTS

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04-09-2008

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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		WO 2004086812 A1	07-10-2004
GB 297151 A	17-09-1928	NONE	

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