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(54) **WAVEGUIDE FOR SHAPING SOUND WAVES**

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H04R 1/28 (2006.01)

(52) **U.S. Cl.**
CPC ***H04R 1/28*** (2013.01)

(58) **Field of Classification Search**
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USPC 181/196, 185, 192, 187, 188, 155
See application file for complete search history.

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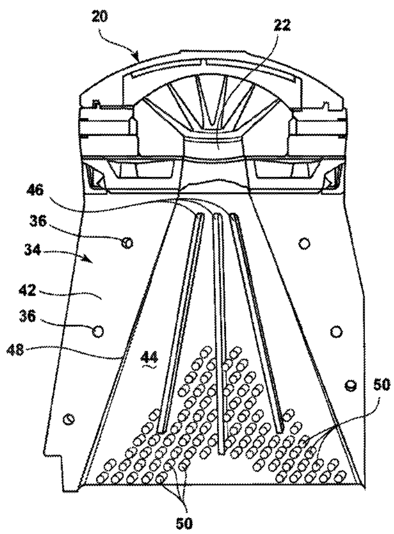
(57) **ABSTRACT**

An acoustic waveguide includes a plurality of projections to redirect sound waves to obtain a desired wave front, such as a flat plane wave front or an asymmetric curved wave front. The waveguide includes two waveguide members that are mirror images of each other. The waveguide members have corresponding vanes and projections. The waveguide includes an essentially circular input opening for alignment with a compression driver and provides a substantially rectangular output opening from the waveguide.

17 Claims, 3 Drawing Sheets



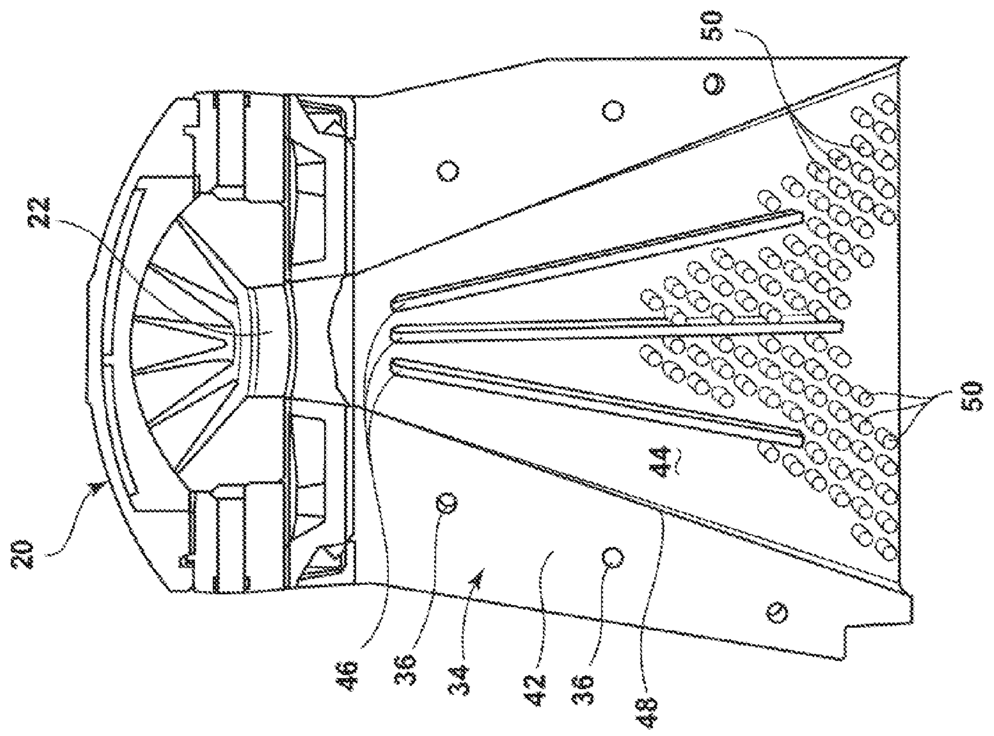


FIG. 2

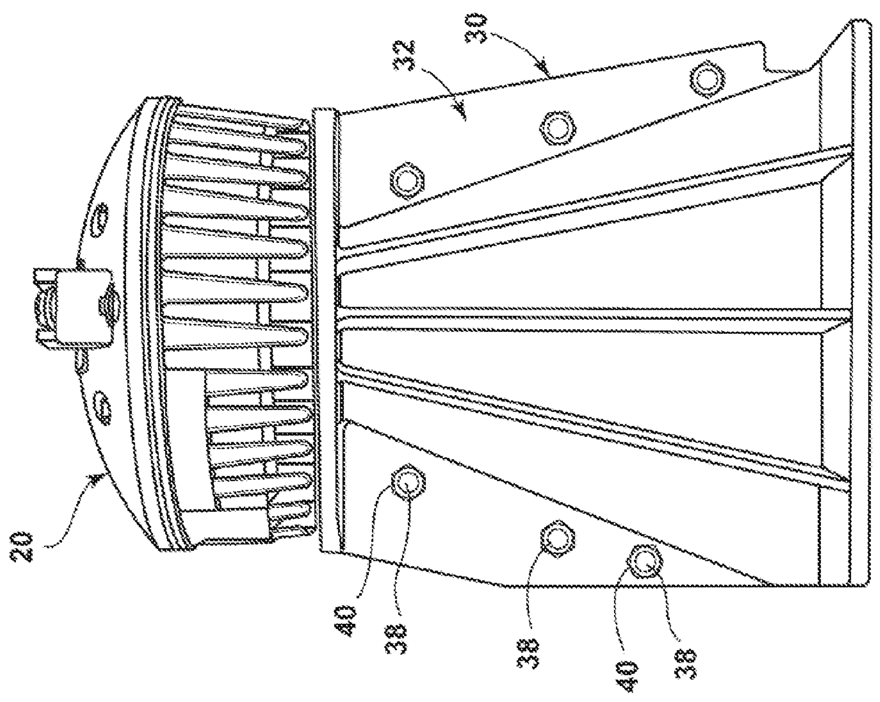


FIG. 1

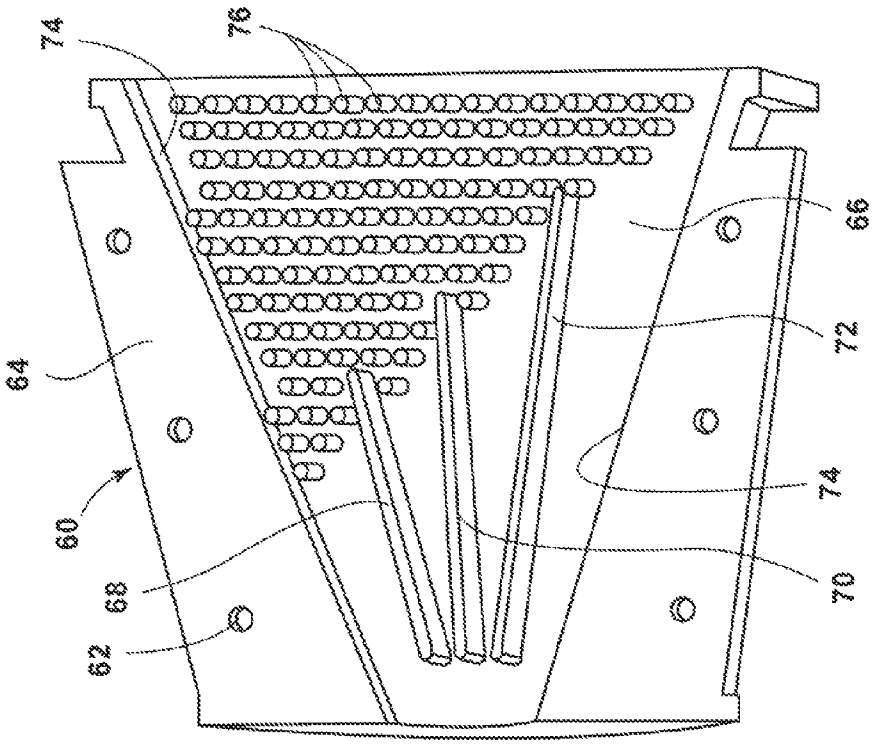


FIG. 5

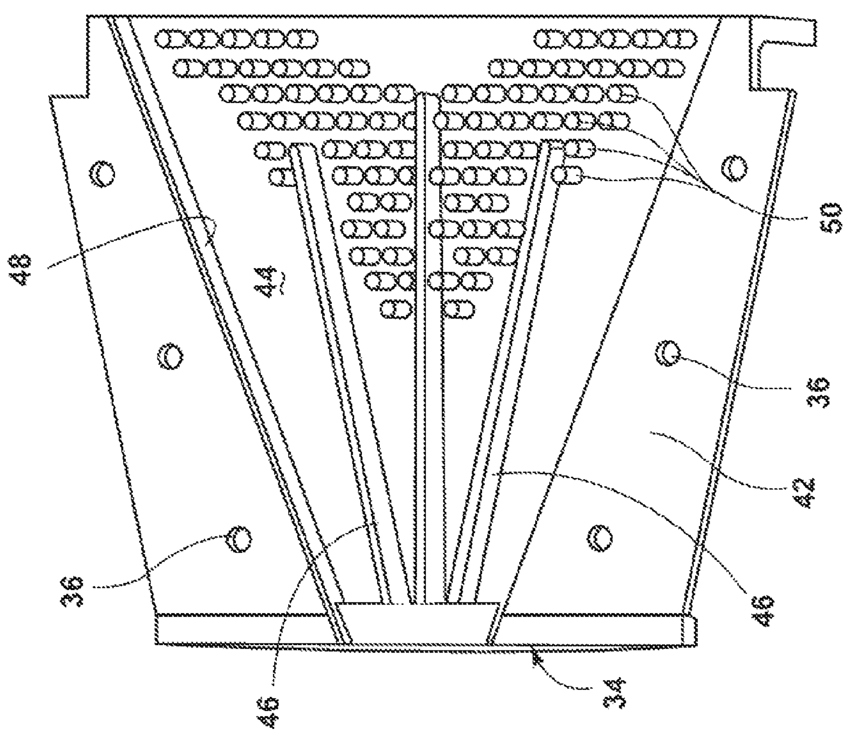


FIG. 3

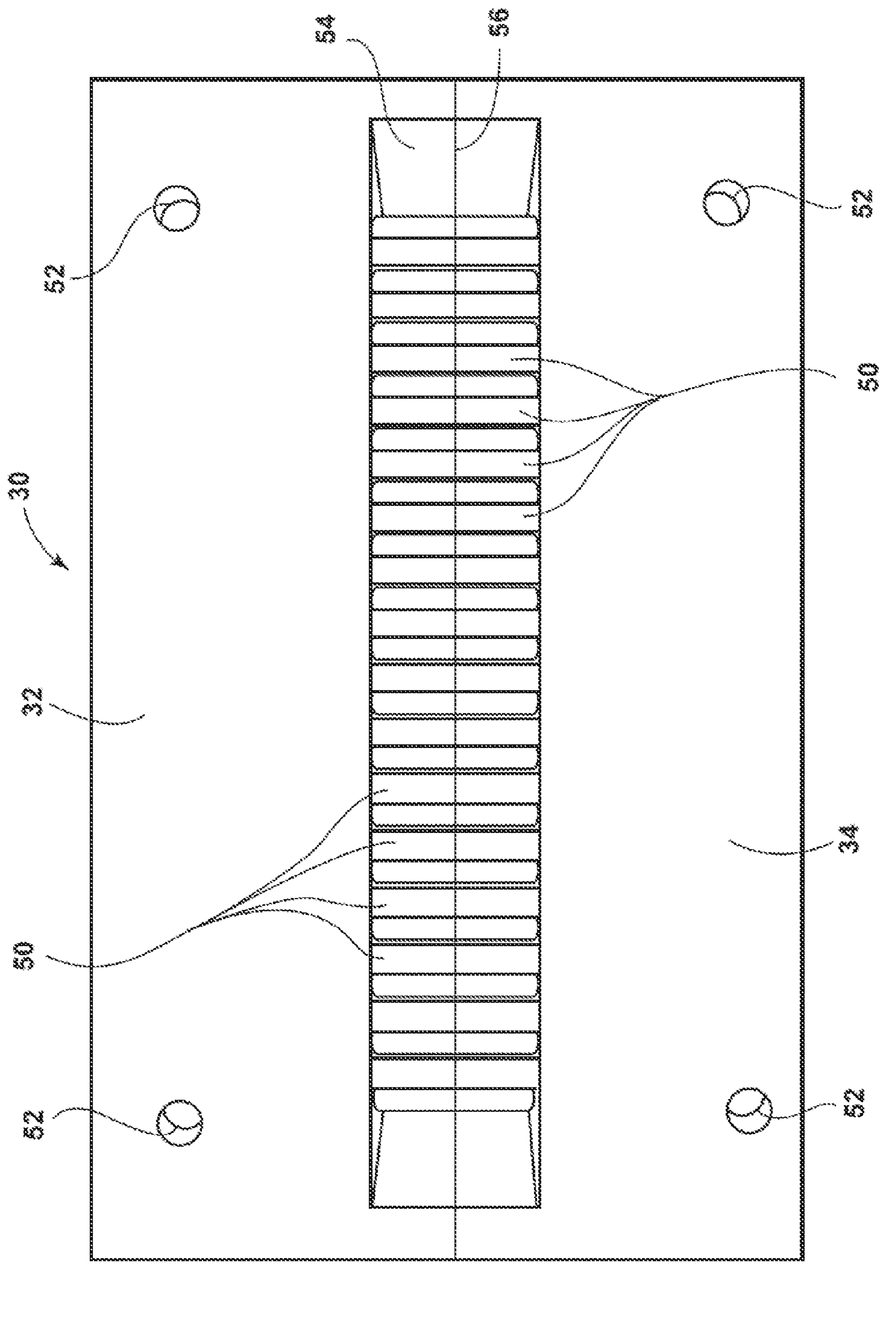


FIG. 4

WAVEGUIDE FOR SHAPING SOUND WAVES

BACKGROUND

The present invention relates to a waveguide for shaping sound waves output by a transducer.

SUMMARY

In one embodiment, the invention provides converts the spherical wave into a plane wave with uniform amplitude over its surface. In other embodiments, the invention creates a predetermined desired curved wave. The result of the invention is better control of sound radiation in angular coverage and in acoustic intensity.

In another embodiment, an acoustic waveguide for shaping waves comprises walls defining a chamber having an input end and an output end with the chamber defined therebetween. An opening at the input end of the waveguide receives sound waves from an acoustic transducer and an opening at the output end of the waveguide outputs sound waves. The waveguide chamber defines a first inner face and a second inner face that is opposing and facing the first inner face. A plurality of projections in alignment is provided on the first inner face and the second inner face and project outwardly therefrom. At least two vanes are disposed on the first inner face of the chamber, the vanes extending from adjacent the opening at the input end and generally toward the output end. The vanes are in alignment with vanes on the second inner face of the chamber.

In some embodiments, the vanes of the waveguide members have a substantially constant thickness along the length thereof. The opening at the input end of the waveguide is typically a circular opening and the opening at the output end is a generally rectangular opening. When assembled, the vanes and the projections typically extend essentially across the entirety of the cavity from the first inner face to the second inner face.

In another embodiment, the waveguide comprises two waveguide members that are mirror images of each other, wherein the first inner face is associated with a first one of the waveguide members and the second inner face is associated with a second one of the waveguide members.

In some embodiments, the waveguide includes a gasket provided between the first waveguide member and the second waveguide member, the gasket providing a seal between the corresponding vanes on the first inner face and the second inner face, and the gasket providing a seal between the projections provided on the first inner face and the corresponding projections provided on the second inner face.

In some embodiments, the plurality of projections comprises at least twenty cylindrical projections. In other embodiments, the plurality of cylindrical projections comprise at least thirty cylindrical projections and the at least two vanes comprises at least three vanes, wherein one of the vanes is centrally oriented along an axis of the waveguide beginning proximate or adjacent the input opening and ending near the output opening.

In one embodiment, at least four of the cylindrical projections are disposed on the inner face a distance from the output opening that is closer to the output opening than a distance from a closest end of the vane to the output opening. In other embodiments, the cylindrical projections are disposed to output an asymmetric curved wavefront or disposed to output a flat plane wave front.

In one embodiment, a horn is disposed at the output end of the waveguide. In another embodiment, a majority of the projections are disposed closer to the output end than to the input end of the waveguide.

In another embodiment of the invention, an acoustic waveguide for shaping waves comprises walls defining a chamber having an input end and an output end with a chamber defined therebetween; an opening at the input end for receiving sound waves from an acoustic transducer; and a substantially rectangular opening at the output end for outputting sound waves. In one embodiment, the chamber defines a first inner face and a second inner face opposing and facing the first inner face. The embodiment includes a plurality of projections provided on the first inner face and projecting outwardly therefrom and at least one vane disposed on the first inner face of the chamber, the vane extending from adjacent the opening at the input end and generally toward the output end.

Other aspects of the invention will become apparent by consideration of the detailed description and accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a perspective view of a transducer unit and waveguide.

FIG. **2** is a cross sectional view of the transducer unit of FIG. **1** and a perspective view of a waveguide plate.

FIG. **3** is a perspective view of the waveguide plate shown in FIG. **2**.

FIG. **4** is a view of the sound wave output end of the waveguide shown in FIG. **1**.

FIG. **5** is a perspective view of another embodiment of the waveguide plate.

DETAILED DESCRIPTION

Before any embodiments of the invention are explained in detail, it is to be understood that the invention is not limited in its application to the details of construction and the arrangement of components set forth in the following description or illustrated in the following drawings. The invention is capable of other embodiments and of being practiced or of being carried out in various ways.

FIGS. **1** and **2** show a transducer unit **20** having a spherical diaphragm and including a compression driver **22** in combination with a waveguide **30**. The waveguide **30** includes a first waveguide member **32** shown in FIG. **1** and a second waveguide member **34** shown in FIG. **2**. Apertures or open bore holes **36** of the waveguide members **32**, **34** are provided in alignment with each other so that fasteners, such as bolts **38** are placed therethrough and secured or locked by nuts **40** or the like to obtain the waveguide **30** shown in FIG. **1**.

FIG. **2** shows the waveguide member **34**, which includes a generally flat connecting section **42** and a chamber defined by a wall or inner face **44**. Within the chamber defined by the inner face **44** are a plurality of elongate vanes **46** defining channels. The inner face **44** is defined by edges **48** of the waveguide member **34**. Further, a plurality of projections **50** are disposed projecting inwardly from the inner face **44**. For the waveguide member **34**, the flat connecting section **42**, the vanes **46**, the edges **48**, and the projections **50** project outwardly essentially the same distance to define a plane. The input end of the waveguide member **34** is shown at the top in FIG. **2** to receive sound waves from the compression driver **22**. The output end of the waveguide member **34** is disposed at the bottom end as shown in FIG. **2**. The waveguide member **34** shown in FIG. **3** corresponds to the waveguide member shown in FIG. **2**.

The waveguide member **32** shown in FIG. **1** is essentially a mirror image of the waveguide member **34**. Thus, when the waveguide members **32**, **34** are joined, a symmetric or an asymmetric waveguide **30** is formed having a chamber with channels defined by inner faces **44**, vanes **46**, edges **48** and projections **50**. The waveguide members **32**, **34** are symmetric or asymmetric depending on the arrangement of the vanes **46** and/or the projections **50**.

FIG. **4** is a view of the output end of the waveguide **30**. FIG. **4** shows a portion of the waveguide member **32** and a portion of the waveguide member **34**. Each of the waveguide members **32**, **34** include open bore holes **52** for the optional attachment of a horn to the output end of the waveguide **30**. FIG. **4** also shows an essentially rectangular opening **54** in the output end of the waveguide **30** that defines a sound output path or opening for outputting a sound wave therefrom. The height of the rectangular opening is significantly greater than the width of the opening. In some embodiments, the height is within a range about of 6 to about 7 times greater than the width of the rectangular opening **54**.

Further, some of the projections **50** provided with each of the waveguide members **32**, **34** are viewable through the rectangular opening **54**. In either event, the projections **50** are disposed in essentially flush alignment with corresponding projections from the other waveguide. Likewise, the vanes of the waveguide member **32** are in alignment with and essentially flush with corresponding vanes of the waveguide member **34**. Therefore, the vanes **46** define a series of passageways or channels between the input end and the output end of the waveguide **30**.

An optional thin gasket **56** is illustrated in FIG. **4**. The gasket **56** reduces or eliminates any amount of gap provided between the vanes **46** or between the corresponding facing projections **50** projecting from the inner faces **44**. In some embodiments, the waveguide members **32**, **34** are molded plastic bodies. Depending on the tolerances and the dimensions of the molded waveguide members **32**, **34** and the vanes **46** and projections **50** thereof, a gasket **56** is not provided.

As shown in FIG. **2**, a large number of projections **50** are provided in channels formed by the vanes **46**. In some embodiments, the projections **50** have a cylindrical shape. In other embodiments, the projections **50** have an elliptical shape, although other shapes are contemplated. In some embodiments, at least twenty projections **50** are required. In other embodiments more than thirty projections **50** are required.

In some embodiments two or more vanes **46** are required for each waveguide **30**. In other embodiments, at least three vanes **46** are contemplated. The vanes **46** have an elongate length beginning near the compression driver **22** at the input end and extending toward the output end. In another embodiment, some of the projections **50** are disposed closer to the rectangular opening **54** at the output end of the waveguide **30** than the vanes **50** are with respect to the rectangular opening at the output end of the waveguide. Moreover, the majority of the projections **50** typically are disposed on the half of the inner face **44** that is closest to the rectangular opening **54** at the output end of the waveguide **30**.

As shown in FIG. **2**, the projections **50** are arranged so that more projections are provided for the inner channels defined by the vanes **46** that have a smaller distance from the compression driver **22** to the rectangular opening **54**. The projections **50** of the arrangement are intended to slow the advance of the sound wave so that the sound wave front exits the rectangular opening **54** shown in FIG. **4** at the same rate/time along the height thereof. Thus, in one embodiment a constant wave front results. In some embodiments, the chamber defined by the inner faces **44** of the waveguide **30** increases in height from the input end to the output end of the waveguide in a first direction as shown in FIG. **2**, the first direction being transverse to a path from the input end to the output end.

In some embodiments, the chamber of the waveguide remains substantially the same size or smaller in a second direction from the input end to the output end, the second direction being transverse to a path from the input end to the output end in a first plane and also transverse with respect to the direction wherein the chamber typically expands to the height shown by the rectangular opening **54** in FIG. **4**. Thus, the width of the opening **54** in this second direction remains narrow for the waveguide as is shown by the width of the rectangular opening **54** of the waveguide **30** in FIG. **4**.

In operation, the compression driver **22** acts as a transducer providing a sound wave, typically in the region of 800 Hz to 20 KHz, to an opening at the input end of the waveguide **30**. The input opening at the input end of the waveguide **30** has a circular shape that essentially matches the dimensions of the compression driver **22**. Within the waveguide **30** shown in FIGS. **2** and **3**, the three vanes **46** divide the input sound energy into essentially four paths or channels. The projections **50** reflect the sound waves so that the sound waves reach the opening **54** at essentially the same time along the length thereof. Thus, a flat planar wave is output from the waveguide.

FIG. **5** is another embodiment of the waveguide. The asymmetric waveguide member **60** shown in FIG. **5** includes open bore apertures **62**, a flat connecting section **64**, an inner face **66**, three vanes **68**, **70**, **72**, edges **74** and a plurality of projections **76**. In the FIG. **5** embodiment, the vanes **68**, **70**, **72** all begin at locations near or proximate the input end similar to the first embodiment of FIGS. **1-4**. The first vane **68**, however, has a shorter length than the middle vane **70** and the third vane **72** has the greatest length. Of the four channels formed, a first outer channel nearest and outwardly from the shortest vane **68** has a path with the most projections **76** to obstruct a sound wave. Proceeding to the channels on the other side of vane **68**, each channel has fewer projections sequentially and the elongate vanes **70**, **72** have progressively longer lengths. Thus, in the FIG. **5** embodiment, the sound wave is output first at the lower end having the path of least resistance and is output more slowly continuously along the entire length of the rectangular opening until reaching the opposing end of the opening. To form a waveguide, a corresponding waveguide member to the waveguide member **60** is provided that is a mirror image thereof. Thus, the projections **76** and the vanes **68**, **70**, **72** for the corresponding waveguide member have the same lengths and sizes as waveguide member **60** to obtain a matching arrangement resulting in an asymmetric wave front.

The pattern and size of the projections **50** affect the properties of the sound wave that is output from the waveguide. The pattern and size of the projections depend in part on the size of the opening for the compression driver **22**.

As shown in FIG. **3**, the plurality of projections **50** are disposed away from the input end of the waveguide **30**, wherein sound travels at least about 40% of the distance from the input end toward the output end of the waveguide before contacting one of the projections. Further, the projections are disposed at least about 65% of the distance from the input end to the output end or rectangular opening **54** for some of the channels formed by vanes of the waveguide.

Thus, the invention provides, among other things, a waveguide that can output a flat wave or other waves from an acoustic transducer. Various features and advantages of the invention are set forth in the following claims.

What is claimed is:

1. An acoustic waveguide for shaping waves comprising:

walls defining a chamber having an input end and an output end with the chamber defined therebetween;

an opening at the input end for receiving sound waves from an acoustic transducer;

an opening at the output end for outputting sound waves;

the chamber opening in a first direction from the input end to the output end, the first direction being transverse to a path from the input end to the output end, the chamber defining a first inner face and a second inner face opposing and facing the first inner face;

a plurality of projections provided on the first inner face and projecting outwardly therefrom; and

at least two vanes disposed on the first inner face of the chamber, the vanes extending from proximate the opening at the input end and generally toward the output end.

2. The waveguide of claim **1**, wherein the vanes have a substantially constant thickness along the length thereof.

3. The waveguide of claim **1**, wherein the opening at the input end comprises a circular opening and the opening at the output end comprises a generally rectangular opening.

4. The waveguide of claim **1**, wherein the vanes and the projections extend substantially across the entirety of the cavity from the first inner face to the second inner face.

5. An acoustic waveguide for shaping waves comprising:

walls defining a chamber having an input end and an output end with the chamber defined therebetween;

an opening at the input end for receiving sound waves from an acoustic transducer;

an opening at the output end for outputting sound waves;

the chamber opening in a first direction from the input end to the output end, the first direction being transverse to a path from the input end to the output end, the chamber defining a first inner face and a second inner face opposing and facing the first inner face;

a plurality of projections provided on the first inner face and projecting outwardly therefrom;

at least two vanes disposed on the first inner face of the chamber, the vanes extending from proximate the opening at the input end and generally toward the output end;

a plurality of projections provided on the second inner face and projecting outwardly therefrom, the projections on the second inner face being in alignment with the projections on the first inner face; and

at least two vanes disposed on the second inner face of the chamber, the vanes on the second inner face of the chamber being in alignment with the vanes on the first face of the chamber,

wherein the waveguide comprises two waveguide members that are mirror images of each other, wherein the first inner face is associated with a first one of the waveguide members and the second inner face is associated with a second one of the waveguide members.

6. The waveguide of claim **5**, further comprising a gasket provided between the first waveguide member and the second waveguide member, the gasket providing a seal between the vanes on the first inner face and the second inner face, and the

gasket providing a seal between the projections provided on the first inner face and the projections provided on the second inner face.

7. The waveguide of claim **1**, wherein the plurality of projections comprises at least twenty cylindrical projections.

8. The waveguide of claim **6**, wherein the plurality of cylindrical projections comprise at least thirty cylindrical projections and the at least two vanes comprises at least three vanes, wherein one of the vanes is centrally oriented along an axis of the waveguide beginning proximate the input opening and ending near the output opening.

9. The waveguide of claim **7**, wherein at least four of the cylindrical projections are disposed on the inner face a distance from the output opening that is closer than a distance from a closest end of the vane from the output opening.

10. The waveguide of claim **1**, wherein the projections comprise cylindrical projections and the cylindrical projections are disposed to output an asymmetric curved wavefront.

11. The waveguide of claim **1**, wherein the projections comprise cylindrical projections and the cylindrical projections are disposed to output a flat plane wave front.

12. The waveguide of claim **1**, further comprising a horn disposed at the output end of the waveguide.

13. The waveguide of claim **1**, wherein a majority of the projections are disposed closer to the output end than to the input end of the waveguide.

14. An acoustic waveguide for shaping waves comprising:

walls defining a chamber having an input end and an output end with a chamber defined therebetween;

an opening at the input end for receiving sound waves from an acoustic transducer;

a substantially rectangular opening at the output end for outputting sound waves;

the chamber opening in a first direction from the input end to the output end, the first direction being transverse to a path from the input end to the output end, the chamber defining a first inner face and a second inner face opposing and facing the first inner face, and the opening chamber in the first direction defining the height of the rectangular opening at the output end;

a plurality of projections provided on the first inner face and projecting outwardly therefrom; and

at least one vane disposed on the first inner face of the chamber, the vane extending from proximate the opening at the input end and generally toward the output end.

15. The acoustic waveguide of claim **14**, wherein the plurality of projections are disposed away from the input end of the waveguide, wherein sound travels at least about 40% of the distance from the input end to the output end of the waveguide before contacting one of the projections.

16. The acoustic waveguide of claim **14**, wherein the at least one vane comprises one of at least three vanes extending from proximate the opening at the input end and generally toward the output end.

17. The waveguide of claim **14**, wherein the plurality of projections comprise at least thirty projections and the at least one vane comprises at least three vanes, wherein one of the vanes is centrally oriented along an axis of the waveguide beginning proximate the input opening and ending near the output opening.

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