(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 1 892 392 A2

(12) # EUROPEAN PATENT APPLICATION

(43) Date of publication:
27.02.2008 Bulletin 2008/09

(51) Int Cl.:
F01N 1/02 *(2006.01)* ***F01N 3/28*** *(2006.01)*

(21) Application number: **07075675.4**

(22) Date of filing: **13.08.2007**

(84) Designated Contracting States:
AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HU IE IS IT LI LT LU LV MC MT NL PL PT RO SE SI SK TR
Designated Extension States:
AL BA HR MK YU

(30) Priority: **16.08.2006 US 504904**

(71) Applicant: **Delphi Technologies, Inc.**
Troy, Michigan 48007 (US)

(72) Inventor: **Andersen, Eric H.**
Grand Blanc, MI 48439 (US)

(74) Representative: **Denton, Michael John et al**
Delphi European Headquarters,
64 avenue de la Plaine de France,
Paris Nord II,
B.P. 65059, Tremblay en France
95972 Roissy Charles de Gaulle Cedex (FR)

(54) **Exhaust treatment devices and methods for reducing sound using the exhaust treatment devices**

(57) Exhaust treatment devices and methods for reducing sound using the exhaust treatment devices are provided. In one exemplary embodiment, the exhaust treatment device includes a housing (14) and a catalyst (15) disposed in the housing. The exhaust treatment device further includes a first end cone (12) having a first inner wall (30) and a first outer wall (32). The first outer wall is secured to the first inner wall at one end (34). The first outer wall is secured to the housing at another end (36). The first inner wall is spaced from the first outer wall such that they define a first cavity (38) therebetween. The first inner wall (30) is spaced from the catalyst (15) at the other end such that an inlet is defined that communicates with the first cavity, wherein exhaust gases flowing through the inlet into the first cavity attenuate sound within the first end cone and the housing.

EP 1 892 392 A2

Description

TECHNICAL FIELD

[0001] This application relates to exhaust treatment devices and methods for reducing sound using the exhaust treatment devices.

BACKGROUND OF THE INVENTION

[0002] Vehicles have utilized mufflers in exhaust systems to reduce sound generated by internal combustion engines. However, a muffler may not be able to reduce sounds at certain frequencies which can be undesirably heard by vehicle occupants.

[0003] Accordingly, the inventors herein have recognized a need for an improved exhaust treatment device that can reduce noise generated in an exhaust system.

SUMMARY OF THE INVENTION

[0004] An exhaust treatment device in accordance with an exemplary embodiment is provided. The exhaust treatment device includes a housing and a catalyst disposed in the housing. The exhaust treatment device further includes
a first end cone having a first inner wall and a first outer wall. The first outer wall is secured to the first inner wall at one end. The first outer wall is secured to the housing at another end. The first inner wall is spaced from the first outer wall at the other end such that the first inner wall and the first outer wall define a first cavity therebetween. The first inner wall is spaced from the catalyst at the other end such that an inlet is defined that communicates with the first cavity, wherein exhaust gases flowing through the inlet into the first cavity attenuate sound within the first end cone and the housing.

[0005] A method for reducing sound in an exhaust treatment device in accordance with another exemplary embodiment is provided. The exhaust treatment device has a housing, a first end cone, and a catalyst. The catalyst is disposed in the housing. The first end cone has a first inner wall and a first outer wall. The first outer wall is secured to the first inner wall at one end. The first outer wall is secured to the housing at another end. The first inner wall is spaced from the first outer wall at the other end such that the first inner wall and the first outer wall define a first cavity therebetween. The first inner wall is spaced from the catalyst at the other end such that an inlet is defined that communicates with the first cavity. The method includes receiving exhaust gases in the first end cone such that a portion of the exhaust gases flow through the inlet into the first cavity of the first end cone. The method further includes attenuating sound within the first end cone and the housing utilizing the portion of the exhaust gases flowing through the inlet into the first cavity of the first end cone.

[0006] An exhaust treatment device in accordance with another exemplary embodiment is provided. The exhaust treatment device includes a housing and a catalyst disposed in the housing. The exhaust treatment device further includes a first end cone having a first inner wall and a first outer wall. The first outer wall is secured to the first inner wall at one end. The first outer wall is secured to the housing at another end. The first inner wall is spaced from the first outer wall at the other end such that the first inner wall and the first outer wall define a first cavity therebetween. The first inner wall is spaced from the catalyst at the other end such that an inlet is defined that communicates with the first cavity. The first inner wall has at least one aperture extending therethrough, wherein exhaust gases flowing through the inlet and the at least one aperture of the first inner wall into the first cavity attenuate sound within the first end cone and the housing.

[0007] A method for reducing sound in an exhaust treatment device in accordance with another exemplary embodiment is provided. The exhaust treatment device has a housing, a first end cone, and a catalyst. The catalyst is disposed in the housing. The first end cone has a first inner wall and a first outer wall. The first outer wall is secured to the first inner wall at one end. The first outer wall is secured to the housing at another end. The first inner wall is spaced from the first outer wall at the other end such that the first inner wall and the first outer wall define a first cavity therebetween. The first inner wall is spaced from the catalyst at the other end such that an inlet is defined that communicates with the first cavity. The first inner wall has at least one aperture extending therethrough. The method includes receiving exhaust gases in the first end cone such that a portion of the exhaust gases flow through the inlet into the first cavity of the first end cone and another portion of the exhaust gases flow through the at least one aperture of the first inner wall into the first cavity. The method further includes attenuating sound within the first end cone and the housing utilizing the portion of the exhaust gases flow through the inlet into the first cavity of the first end cone and the portion of the exhaust gases flowing through the at least one aperture of the first inner wall into the first cavity.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008]

Figure 1 is a block diagram of an exemplary Helmholtz resonator;

Figure 2 is a sound attenuation curve associated with the Helmholtz resonator of Figure 1;

Figure 3 is a block diagram of another exemplary Helmholtz resonator;

Figure 4 is a sound attenuation curve associated with the Helmholtz resonator of Figure 3;

Figure 5 is a block diagram of another exemplary Helmholtz resonator;

Figure 6 is a sound attenuation curve associated with the Helmholtz resonator of Figure 5;

Figure 7 is a cross-sectional schematic of an exhaust treatment device having a Helmholtz resonator in accordance with an exemplary embodiment;

Figure 8 is a sound attenuation curve associated with a first end cone of the exhaust treatment device of Figure 7;

Figure 9 is a sound attenuation curve associated with another end cone, without a Helmholtz resonator, of a catalytic converter;

Figure 10 is a sound attenuation curve associated with a first end cone of the exhaust treatment device of Figure 7 obtained utilizing simulation software;

Figure 11 is a sound attenuation curve associated with a second end cone of the exhaust treatment device of Figure 7 obtained utilizing simulation software;

Figure 12 is a partial cross-sectional schematic of an exhaust treatment device having a Helmholtz resonator in accordance with another exemplary embodiment; and

Figure 13 is a partial cross-sectional schematic of an exhaust treatment device having a Helmholtz resonator in accordance with another exemplary embodiment.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0009] Before describing the exhaust treatment devices in accordance with exemplary embodiments, a brief description of a Helmholtz resonators will be discussed. The sound attenuation characteristics of a Helmholtz resonator are determined based on a volume of a cavity, a total area of an inlet into the cavity, and a length of the inlet into the cavity. In particular, a center frequency where sound is attenuated by a Helmholtz resonator is predicted by using the following equation:

$$f = 180 / (Ao/Le\ V)^{1/2}$$

where

f corresponds to the sound center frequency where a greatest sound attenuation is obtained;

Ao corresponds to the total inlet area;

Le corresponds to the effective length of the inlet which is obtained utilizing the following equation: Le = actual inlet length + end effect constant B; and

V corresponds to the volume of a cavity coupled to the inlet.

Further, the amount of sound attenuation by a Helmholtz resonator is proportional to the following equation:

$$[\,(Co\ V)^{1/2} / \ 2S\ ],$$

wherein

Co corresponds to the inlet conductivity and is obtained utilizing the following equation: Co = Ao/Le; and

S corresponds to the cross-sectional area of the inlet.

[0010] Referring now to Figures 1-6, exemplary configurations of simple Helmholtz resonators are illustrated. In particular, the Helmholtz resonators will be utilized to illustrate how the three variables (i.e. a total inlet area, an inlet length, and a cavity volume) may be varied to select sound frequency ranges to attenuate. Referring to Figures 1 and 2, a Helmholtz resonator 4 includes a cavity and an inlet. The attenuation curve 5 indicates that the Helmholtz resonator 4 attenuates sound across a relatively large frequency range. Referring to Figures 3 and 4, a Helmholtz resonator 6 includes a cavity and an inlet. The attenuation curve 7 indicates that the Helmholtz resonator 6 attenuates sound across a frequency range smaller than the frequency range of the Helmholtz resonator 4. Referring to Figures 5 and 6, a Helmholtz resonator 8 includes a cavity and an inlet. The attenuation curve 7 indicates that the Helmholtz resonator 8 attenuates sound across a frequency range smaller than the frequency range of Helmholtz resonator 6.

[0011] Referring to Figure 7, an exhaust treatment device 10 in accordance with an exemplary embodiment is illustrated. The exhaust treatment device 10 is provided to reduce emissions from an internal combustion engine (not shown). Further, the exhaust treatment device 10 is provided to reduce sound within predetermined frequency ranges within the exhaust treatment device 10. The exhaust treatment device 10 includes an end cone 12, a housing 14, a catalyst 15, and an end cone 16.

[0012] The end cone 12 is provided to direct exhaust gases into the exhaust treatment device 10. The end cone 12 is further configured as a Helmholtz resonator to attenuate noise within a predetermined frequency range. The end cone 12 includes an inner wall 30 and an outer wall 32. The inner wall 30 and the outer wall 32 are constructed from stainless steel. The inner wall 30 is coupled to the outer wall 32 at an end 34 and defines a flow path 33 therein. The inner wall 30 is disposed in a spaced relationship with the outer wall 32 at an end 36, such that a cavity 38 is defined between the inner wall 30 and the outer wall 32. The outer wall 32 is further coupled at the end 36 to a wall 50 of the housing 14. Further, an annular inlet 40 is defined between the inner wall 30 and a catalyst 15 disposed within the housing 14. Thus, the inlet 40 and the cavity 38 define a Helmholtz resonator configured to attenuate sound within the exhaust treatment device 10 within a predetermined frequency range. In particular, exhaust gases flowing through the flow path 33 and the inlet 40 into the cavity 38 will attenuate sound within the end cone 12. Referring to Figure 8, during operation, the end cone 12 can attenuate sound in a frequency range centered at 1300 Hertz as indicated by the empirically determined sound attenuation curve 100. In particular, the end cone can attenuate sound 20 decibels at 1300 Hertz. Referring to Figure

9, in contrast, an end cone not configured to have a Helmholtz resonator does not reduce sound as much as the end cone 12, as indicated by the empirically determined sound attenuation curve 110. It should be noted that in alternative embodiments, the end cone 12 can be configured to attenuate sound in frequency ranges centered at frequencies greater than 1300 Hertz or less than 1300 Hertz.

[0013] Referring to Figure 10, a simulation program was utilized to generate a sound attenuation curve 112 indicative of a predicted sound attenuation characteristic of the end cone 12. As illustrated, the sound attenuation curve 112 predicts that the end cone 12 can attenuate sound in a frequency range centered at 1267 Hertz. In particular, the end cone 12 can attenuate sound 16.27 decibels at 1267 Hertz.

[0014] Referring to Figure 7, the housing 14 is provided to enclose a catalyst 15 therein. The housing 14 includes a tubular wall 50 and an insulation layer 52. The insulation layer 52 is disposed against an inner surface of the tubular wall 50. The insulation layer 52 is substantially ring-shaped and defines a region for receiving the catalyst 15 therein. The wall 50 is coupled at an end 54 to the outer wall 32 of the end cone 12. The wall 50 is further coupled at an end 56 to an outer wall 62 of the end cone 16.

[0015] The catalyst 15 is provided to reduce certain exhaust gas constituents in exhaust gases received from an internal combustion engine (not shown). In one exemplary embodiment, the catalyst 15 comprises a component of a catalytic converter. It should be noted that the catalyst 15 can comprise any component capable of reducing at least one exhaust gas constituent from an internal combustion engine.

[0016] The end cone 16 is provided to direct exhaust gases from the catalyst 15 through the flow path 70. The end cone 16 is further configured as a Helmholtz resonator to attenuate noise within a predetermined frequency range. The end cone 16 includes an inner wall 60 and an outer wall 62. The inner wall 60 and the outer wall 62 are constructed from stainless steel, in one exemplary embodiment. The inner wall 60 is coupled to the outer wall 62 at an end 74. The inner wall 60 is disposed in a spaced relationship with the outer wall 62 at an end 72, such that a cavity 76 is defined between the inner wall 60 and the outer wall 62. Further, a portion of the inner wall 60 is embedded at the end 72 in the insulation layer 52. The outer wall 62 is further coupled at the end 72 to the wall 50 of the housing 14. The outer wall 62 includes apertures 64, 66, 68 extending therethrough. Thus, the apertures 64, 66, 68 and the cavity 76 define a Helmholtz resonator configured to attenuate sound within the end cone 16 within a predetermined frequency range. In particular, exhaust gases flowing through the apertures 64, 66, 68 into the cavity 76 will attenuate sound within the end cone 16. Referring to Figure 11, a simulation program was utilized to generate a sound attenuation curve 114 indicative of a predicted attenuation characteristic of the end cone 16. As illustrated, the sound attenuation curve 114 predicts that the end cone 16 can attenuate sound in a frequency range centered at 142 Hertz. In particular, the end cone 16 can attenuate sound 58 decibels at 142 Hertz. It should be noted that in alternative embodiments, the end cone 16 can be configured to attenuate sound in frequency ranges centered at frequencies less than 142 Hertz or greater than 142 Hertz.

[0017] Referring to Figure 12, a partial view of an exhaust treatment device 130 in accordance with another exemplary embodiment is illustrated. The exhaust treatment device 130 is provided to reduce emissions from an internal combustion engine (not shown). Further, the exhaust treatment device 130 is provided to reduce sound within predetermined frequency ranges within the exhaust treatment device 130. The exhaust treatment device 130 includes an end cone 132, a housing 134, a catalyst 135, and another end cone (not shown) coupled to the housing 134.

[0018] The end cone 132 is provided to direct exhaust gases into the exhaust treatment device 130. The end cone 132 is further configured as a Helmholtz resonator to attenuate noise within a predetermined frequency range. The end cone 132 includes an inner wall 140 and an outer wall 142. The inner wall 140 and the outer wall 142 are constructed from stainless steel, in one exemplary embodiment. The inner wall 140 is coupled to the outer wall 142 at an end 146 and defines a flow path 144 therein. The inner wall 140 is disposed in a spaced relationship with the outer wall 142 at an end 148, such that a relatively large cavity 150 is defined between the inner wall 140 and the outer wall 142. The outer wall 32 is further coupled at the end 148 to a wall of the housing 134. Further, an annular inlet 152 is defined between the inner wall 140 and the catalyst 135 disposed within the housing 134. Thus, the inlet 152 and the cavity 150 define a Helmholtz resonator configured to attenuate sound within the exhaust treatment device 130 within a predetermined frequency range. In particular, exhaust gases flowing through the flow path 144 and the inlet 152 into the cavity 150 will attenuate sound within the end cone 132.

[0019] The housing 134 is provided to enclose the catalyst 135 therein and has a configuration similar to housing 14 discussed above.

[0020] Referring to Figure 13, a partial view of another exhaust treatment device 170 in accordance with an exemplary embodiment is illustrated. The exhaust treatment device 170 is provided to reduce emissions from an internal combustion engine (not shown). Further, the exhaust treatment device 170 is provided to reduce sound within predetermined frequency ranges within the exhaust treatment device 170. The exhaust treatment device 170 includes an end cone 172, a housing 174, a catalyst 175, and another end cone (not shown) coupled to the housing 174.

[0021] The end cone 172 is provided to direct exhaust gases into the exhaust treatment device 170. The end cone 172 is further configured as a Helmholtz resonator to attenuate noise within a predetermined frequency range. The end cone 172 includes an inner wall 173 and an outer wall 176. The inner wall 173 and the outer wall 176 are constructed from stainless steel. The inner wall 173 is coupled to the outer wall 176 at an end 186 and defines a flow path 178 therein. The inner wall 173 is disposed in a spaced relationship with the outer wall 176 at an end 188, such that a relatively large cavity 190 is defined between the inner wall 173 and the outer wall 176. The inner wall 173 includes apertures 180, 182, and 184 extending therethrough. The outer wall 176 is further coupled at the end 188 to a wall of the housing 174. Further, an annular inlet 192 is defined between the inner wall 173 and the catalyst 175 disposed within the housing 174. Thus, the annular inlet 192, the apertures 180, 182, 184, and the cavity 150 define a Helmholtz resonator configured to attenuate sound within the end cone 172 within a predetermined frequency range. In particular, exhaust gases flowing through: (i) the flow path 144 and the inlet 152 into the cavity 190, and (ii) through the flow path 178 and the apertures 180, 182, 184 into the cavity 190, will attenuate sound within the end cone 172.

[0022] The housing 174 is provided to enclose the catalyst 175 therein and has a configuration similar to the housing 14 discussed above.

[0023] The exhaust treatment devices and the methods for reducing sound represent a substantial improvement over other devices and methods. In particular, the exhaust treatment devices and the methods provide a technical effect reducing sound within exhaust treatment devices within predetermined frequency ranges, which are not substantially attenuated by vehicle mufflers. While the invention has been described with reference to exemplary embodiments, it will be understood by those skilled in the art that various changes may be made and equivalents may be substituted for elements thereof without departing from the scope of the invention. In addition, many modifications may be made to adapt a particular situation or material to the teachings of the invention without departing from the essential scope thereof. Therefore, it is intended that the invention not be limited to the particular embodiment disclosed for carrying out this invention, but that the invention will include all embodiments falling within the scope of the appended claims. Moreover, the use of the terms first, second, etc. do not denote any order or importance, but rather the terms first, second, etc. are used to distinguish one element from another. Furthermore, the use of the terms a, an, etc. do not denote a limitation of quantity, but rather denote the presence of at least one of the referenced item.

Claims

1. An exhaust treatment device, comprising:

   a housing;
   a catalyst disposed in the housing; and
   a first end cone having a first inner wall and a first outer wall, the first outer wall secured to the first inner wall at one end, the first outer wall being secured to the housing at another end, the first inner wall being spaced from the first outer wall at the other end such that the first inner wall and the first outer wall define a first cavity therebetween, the first inner wall being spaced from the catalyst at the other end such that an inlet is defined that communicates with the first cavity, wherein exhaust gases flowing through the inlet into the first cavity attenuate sound within the first end cone and the housing.

2. The exhaust treatment device of claim 1, wherein the exhaust gases flowing through the inlet into the first cavity attenuate sound at a predetermined frequency in the first end cone and the housing.

3. The exhaust treatment device of claim 1, wherein the predetermined frequency is based on a volume of the first cavity, an area of the inlet, and a length of the inlet.

4. The exhaust treatment device of claim 1, further comprising:

   a second end cone disposed on the housing on an end of the housing opposite the first end cone, the second end cone having a second inner wall and a second outer wall, the second outer wall secured to the second inner wall at a first end, the second outer wall being secured to the housing at a second end, a portion of the second inner wall being spaced from the second outer wall such that the second inner wall and the second outer wall define a second cavity therebetween, the second inner wall having at least one aperture extending therethrough, wherein exhaust gases flowing through the at least one aperture into the second cavity attenuate sound within the second end cone and the housing.

5. The exhaust treatment device of claim 4, wherein exhaust gases flowing through the inlet into the first cavity attenuate sound at a first predetermined frequency and exhaust gases flowing through the at least one aperture into the second cavity attenuate sound at a second predetermined frequency, the second predetermined frequency differing from the first predetermined frequency.

6. A method for reducing sound in an exhaust treatment device, the exhaust treatment device having a housing, a first end cone, and a catalyst, the catalyst being disposed in the housing, the first end cone having a first inner wall and a first outer wall, the first outer wall being secured to the first inner wall at one end,

the first outer wall being secured to the housing at another end, the first inner wall being spaced from the first outer wall at the other end such that the first inner wall and the first outer wall define a first cavity therebetween, the first inner wall being spaced from the catalyst at the other end such that an inlet is defined that communicates with the first cavity, the method comprising:

receiving exhaust gases in the first end cone such that a portion of the exhaust gases flow through the inlet into the first cavity of the first end cone; and
attenuating sound within the first end cone and the housing utilizing the portion of the exhaust gases flowing through the inlet into the first cavity of the first end cone.

7. An exhaust treatment device, comprising:

a housing;
a catalyst disposed in the housing; and
a first end cone having a first inner wall and a first outer wall, the first outer wall secured to the first inner wall at one end, the first outer wall being secured to the housing at another end, the first inner wall being spaced from the first outer wall at the other end such that the first inner wall and the first outer wall define a first cavity therebetween, the first inner wall being spaced from the catalyst at the other end such that an inlet is defined that communicates with the first cavity, the first inner wall having at least one aperture extending therethrough, wherein exhaust gases flowing through the inlet and the at least one aperture of the first inner wall into the first cavity attenuate sound within the first end cone and the housing.

8. The exhaust treatment device of claim 7, wherein the exhaust gases flowing through the inlet and the at least one aperture of the first inner wall into the first cavity attenuate sound at a predetermined frequency in the first end cone and the housing.

9. The exhaust treatment device of claim 8, wherein the predetermined frequency is based on a volume of the first cavity, a combined area of the inlet and the aperture, a length of the inlet, and a thickness of the first inner wall proximate the aperture.

10. The exhaust treatment device of claim 7, further comprising:

a second end cone disposed on the housing on an end of the housing opposite the first end cone, the second end cone having a second inner wall and a second outer wall, the second outer wall secured to the second inner wall at a first end, the second outer wall being secured to the housing at a second end, a portion of the second inner wall being spaced from the second outer wall such that the second inner wall and the second outer wall define a second cavity therebetween, the second inner wall having at least one aperture extending therethrough, wherein exhaust gases flowing through the at least one aperture of the second inner wall into the second cavity attenuate sound within the second end cone and the housing.

11. The exhaust treatment device of claim 10, wherein exhaust gases flowing through the inlet and the at least one aperture of the first inner wall into the first cavity attenuate sound at a first predetermined frequency and exhaust gases flowing through the at least one aperture of the second inner wall into the second cavity attenuate sound at a second predetermined frequency, the second predetermined frequency differing from the first predetermined frequency.

12. A method for reducing sound in an exhaust treatment device, the exhaust treatment device having a housing, a first end cone, and a catalyst, the catalyst being disposed in the housing, the first end cone having a first inner wall and a first outer wall, the first outer wall being secured to the first inner wall at one end, the first outer wall being secured to the housing at another end, the first inner wall being spaced from the first outer wall at the other end such that the first inner wall and the first outer wall define a first cavity therebetween, the first inner wall being spaced from the catalyst at the other end such that an inlet is defined that communicates with the first cavity, the first inner wall having at least one aperture extending therethrough, the method comprising:

receiving exhaust gases in the first end cone such that a portion of the exhaust gases flow through the inlet into the first cavity of the first end cone and another portion of the exhaust gases flow through the at least one aperture of the first inner wall into the first cavity; and
attenuating sound within the first end cone and the housing utilizing the portion of the exhaust gases flow through the inlet into the first cavity of the first end cone and the portion of the exhaust gases flowing through the at least one aperture of the first inner wall into the first cavity.

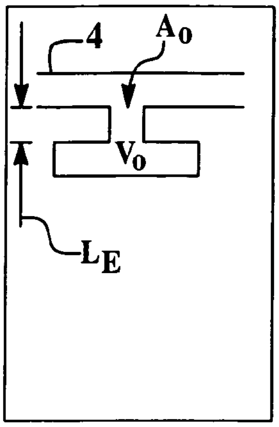

Figure 1

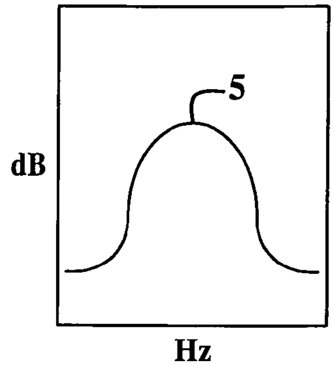

Figure 2

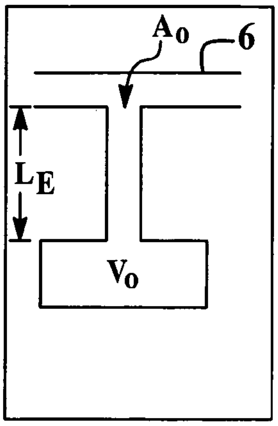

Figure 3

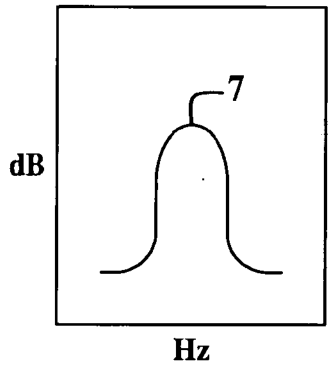

Figure 4

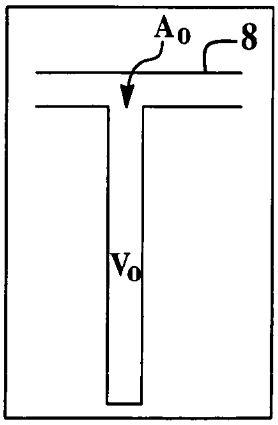

Figure 5

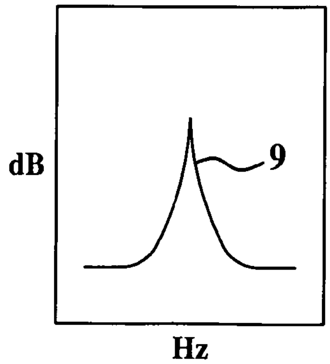

Figure 6

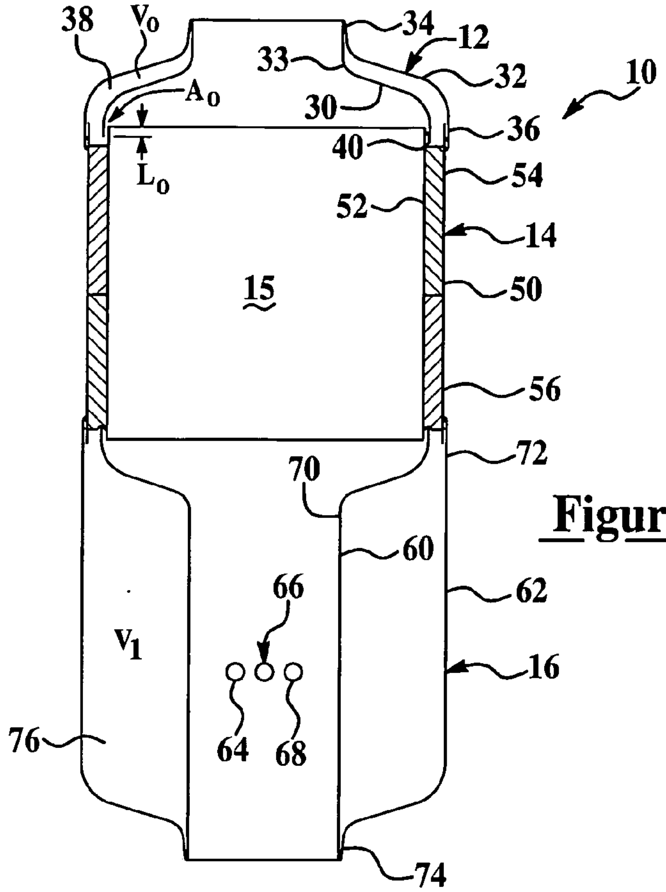

Figure 7

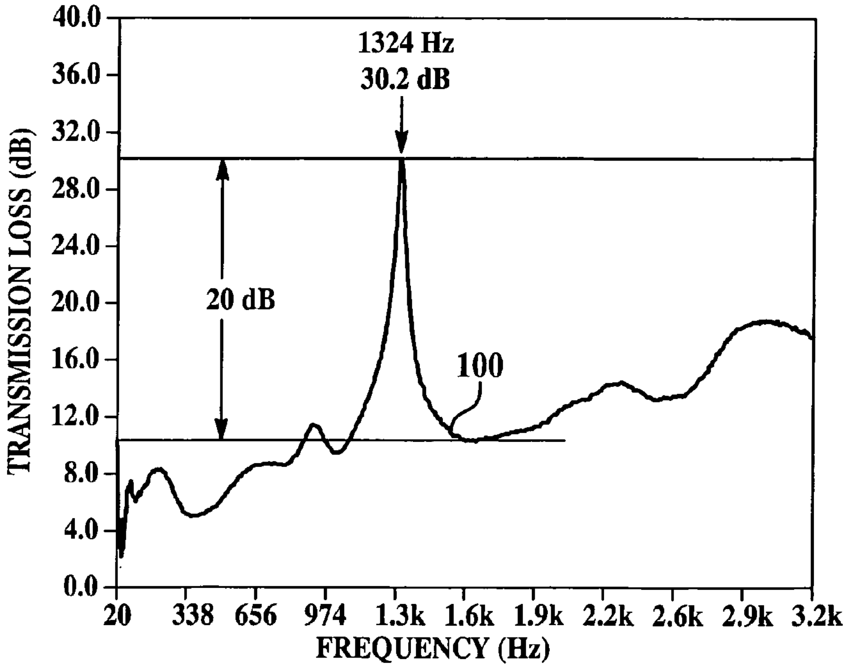

Figure 8

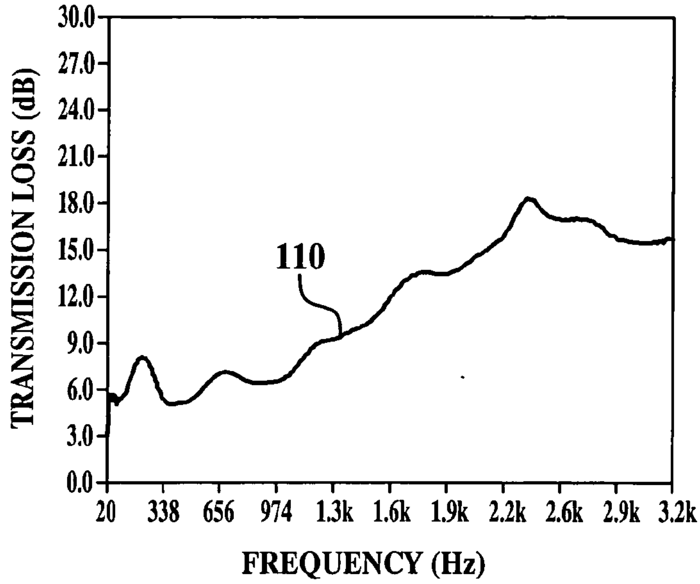

Figure 9

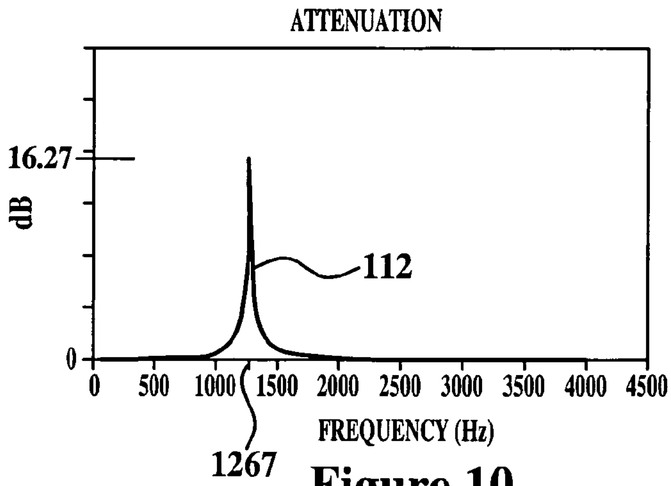

Figure 10

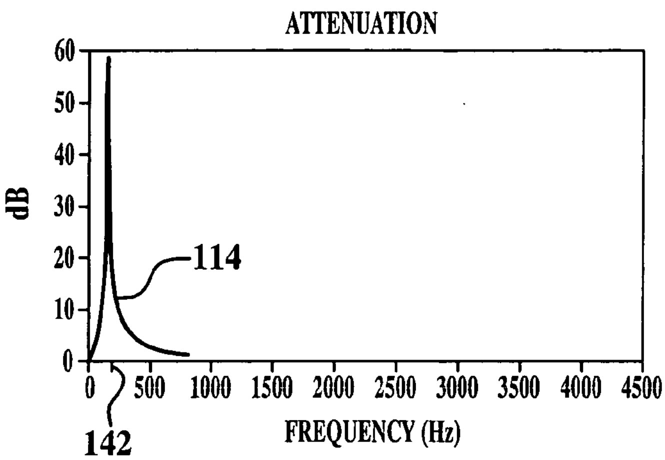

Figure 11

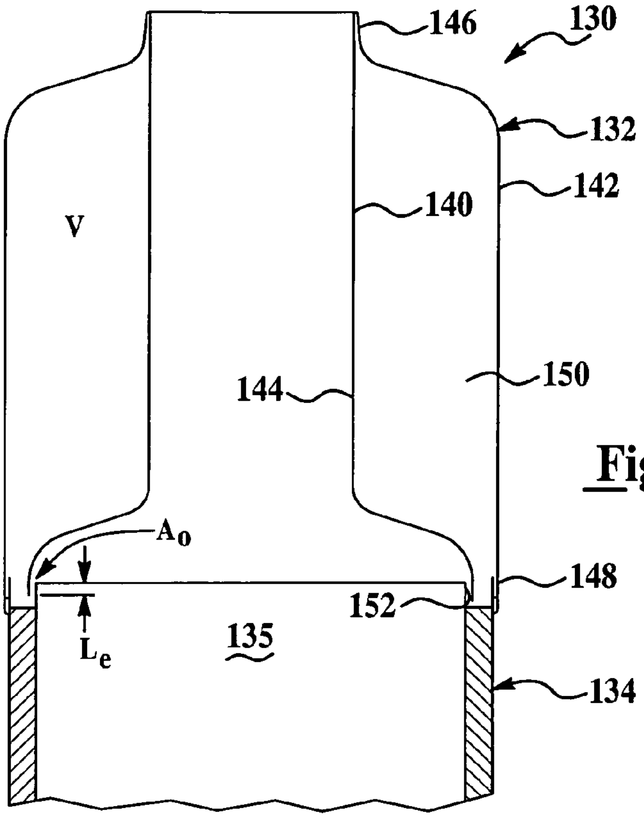

Figure 12

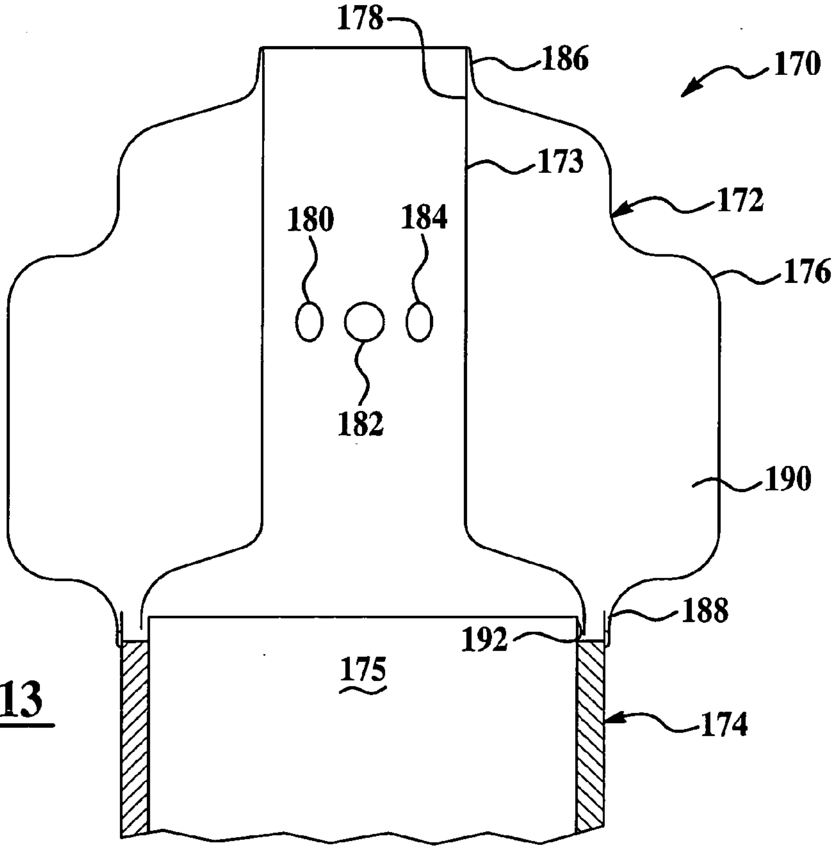

Figure 13