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(54) Active exhaust gas muffler.

(57) An active muffler (1) wherein a metal casing (3) defines a parallelepiped inner cavity (8) divided into a first (8a) and second (8b) chamber by a rectangular panel (13) of material impervious to heat. The panel (13) presents a central through opening (19), the peripheral edge of which contacts the peripheral edge (30) of the cone of a loudspeaker (6) housed in the first chamber (8a) and supplied by an electronic active noise reducing system. The second chamber (8b) houses a passive muffler (35) supplied with the exhaust gas produced by a vehicle engine.

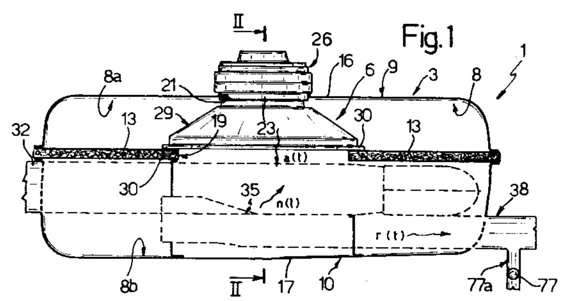


Fig.1

EP 0 674 097 A1

The present invention relates to an active exhaust gas muffler.

Known active exhaust gas mufflers comprise a metal casing defining an inner chamber housing one or more loudspeakers fitted to the casing; a gas inflow pipe extending through a first lateral wall of the casing and terminating close to the loudspeaker opening; and a gas outflow pipe extending from a second lateral wall of the casing.

The loudspeaker is supplied by the central unit of a noise reducing electronic system, and generates an antivibration (antinoise) a(t) which is added to the vibration (noise) n(t) produced by the engine to at least partially cancel the vibration n(t) inside the chamber of the muffler.

The high temperature (roughly 600 °C) at which the exhaust gas is fed into the muffler by the inflow pipe results in considerable heating of the muffler chamber and hence the loudspeaker.

Which heating, in the case of known mufflers, is a possible source of irreparable damage to the loudspeaker.

It is an object of the present invention to provide an active muffler designed to overcome the aforementioned drawback typically associated with known mufflers.

According to the present invention, there is provided an active exhaust gas muffler comprising:

- an outer casing defining at least one inner cavity communicating with a gas inflow pipe and a gas outflow pipe; and
- at least one transducer for generating a vibration a(t) directed into said cavity;

  characterized in that it comprises means for reducing the temperature of at least part of said transducer.

The present invention will be described with reference to the accompanying drawings, in which:

Figure 1 shows a simplified longitudinal section of an active muffler in accordance with the teachings of the present invention;

Figure 2 shows a section of the muffler along line II-II in Figure 1;

Figure 3 shows a muffler in accordance with the teachings of the present invention and as applied to a vehicle exhaust system;

Figure 4 shows a simplified longitudinal section of a first variation of the muffler according to the present invention;

Figure 5 shows a second variation of the Figure 1 muffler;

Figure 6 shows a third variation of the Figure 1 muffler;

Figure 7 shows a muffler of the Figure 4-6 type and as applied to a vehicle exhaust system.

Number 1 in Figure 1 indicates an active muffler comprising a hollow metal casing 3; and a transducer 6, more specifically a loudspeaker, housed partly inside the cavity 8 defined by casing 3.

Casing 3 is substantially parallelepiped, and comprises two opposite half shells 9, 10 connected to each other and presenting respective peripheral end edges 9a, 10a.

According to the present invention, muffler 1 also comprises a substantially rectangular partition panel 13 extending inside cavity 8, parallel to opposite rectangular walls 16, 17 of casing 3.

Panel 13 thus divides cavity 8 into a first chamber 8a defined by panel 13, wall 16 and the lateral walls of casing 3; and a second chamber 8b defined by panel 13, wall 17 and the lateral walls of casing 3.

Panel 13 is made of material impervious to heat, e.g. fiberglass, and presents a circular, central through opening 19.

Wall 16 presents a central through hole 21 engaged by a peripheral portion 23 of the permanent magnet 26 of loudspeaker 6. More specifically, permanent magnet 26 is substantially cylindrical, and extends outwards from wall 16 of casing 3.

Loudspeaker 6 also comprises a metal cone (not shown) supported on a truncated-cone-shaped support 29 extending between peripheral portion 23 of magnet 26 and panel 13. More specifically, support 29 presents a peripheral end edge 30 contacting the peripheral edge of opening 19.

Muffler 1 presents a gas inflow pipe 32 extending through a first lateral wall of casing 3, and communicating with a known passive muffler 35 (shown schematically) comprising a number of pipes housed inside chamber 8b.

Muffler 1 also presents a gas outflow pipe 38 extending through a second lateral wall of casing 3, and to the inlet of which the gas from the outlet (not shown) of device 35 is supplied.

In the Figure 3 example, muffler 1 is connected to the exhaust system 60 of a vehicle (not shown), comprising an exhaust pipe 61 extending between the exhaust manifold 63 of an internal combustion engine 65 and muffler 1.

Exhaust system 60 also comprises a catalytic converter 67 located along exhaust pipe 61, upstream from muffler 1.

Muffler 1 is connected to an electronic noise reducing system wherein a known electronic control unit 69 is input connected to a sync sensor 70 of engine 65, and to a vibration sensor 74 (e.g. a microphone) located along pipe 61, between converter 67 and muffler 1.

Control unit 69 is also supplied with a signal from a vibration sensor 77 (e.g. a microphone) fitted to the end of a cylindrical pipe 77a (Figures 1 and 3) extending radially from outflow pipe 38 of muffler 1.

Control unit 69 comprises a final power stage 78 for supplying loudspeaker 6 of muffler 1 over line 79.

In actual use, in response to the signals from sensors 70 and 74, the control unit generates a signal for driving loudspeaker 6 which produces an antivibration (antinoise) a(t) in phase opposition to the vibration (noise) n(t) produced by engine 65.

As shown in Figure 1, the antivibration a(t) generated by loudspeaker 6 travels through opening 19 into chamber 8b where it interacts with the vibration n(t) from passive muffler 35.

More specifically, vibrations a(t) and n(t) are added inside chamber 8b, and the residual vibration r(t) = n(t) + a(t) issues from outflow pipe 38 and is detected by sensor 77.

Sensor 77 supplies control unit 69 with a feedback signal proportional to the amplitude of residual vibration r(t), and on the basis of which the drive signal of loudspeaker 6 is closed-loop modified to maximize interference between antivibration a(t) and vibration n(t).

Muffler 1 clearly provides, therefore, for reducing the temperature of loudspeaker 6.

The chamber 8a housing loudspeaker 6, in fact, is both physically and thermally separated by panel 13 from the chamber 8b into which the exhaust gas produced by engine 65 is fed directly, so that the temperature inside chamber 8a is lower (by roughly 300-400 ° C) than in chamber 8b.

Moreover, by being fitted outside casing 3, magnet 26 is subjected to and cooled dynamically by the air flowing about muffler 1 when the vehicle (not shown) is in motion, thus preventing the temperature of magnet 26 from exceeding the Curie point at which it is demagnetized.

Opening 19 (Figure 2) may be closed by an elastic membrane M permeable to sound and impermeable to heat, for delaying heat transmission from chamber 8b to chamber 8a and further reducing the temperature of loudspeaker 6. Elastic membrane M may be integrated with or replaced by a grill structure (not shown) fitted to casing 3, facing opening 19, and presenting a number of fins (not shown) for dissipating heat towards the outer casing.

Casing 3 may also present one or more openings (not shown) for permitting air intake to and so internally cooling chamber 8b.

Clearly, changes may be made to the muffler as described and illustrated herein without, however, departing from the scope of the present invention.

In particular, Figure 4 shows a first variation 1a of the Figure 1 muffler, which comprises an elongated first casing 103, and a cylindrical elongated second casing 105 connected to and located to the side of first casing 103.

More specifically, second casing 105 defines an inner chamber 121 in turn defined by a cylindrical tubular wall 107 coaxial with an axis 109, by a flat circular wall 112 perpendicular to axis 109, and by a truncated-cone-shaped end wall 115 connected to a cylindrical gas outflow pipe 118 extending coaxially with axis 109 and outwards of casing 105.

Muffler 1a also comprises a cylindrical gas inflow pipe 126 (the end portion of which is shown) extending coaxially with axis 109 through wall 112 (to which it is welded) and terminating inside chamber 121.

First casing 103 defines a substantially parallelepiped inner chamber 129 in turn defined by two opposite rectangular walls 132, 133, by two opposite rectangular lateral walls 135, 136, and by a front and a rear wall (not shown).

First and second casings 103, 105 are connected to each other by a rectangular tubular appendix 140 extending between an intermediate portion of cylindrical wall 107 and a central portion of wall 132. Appendix 140 defines a rectangular conduit 142 crosswise to axis 109 and connecting chambers 121 and 129, so that chamber 129 is branch connected in relation to chamber 121 and conduit 142.

Conduit 142 is fitted with a sheet 157 of material (e.g. rock wool) permeable to sound vibration and for preventing (or at least delaying) heat transmission from chamber 121 to chamber 129.

First casing 103 houses a pair of loudspeakers 145, each comprising a cone 147 with its opening facing wall 132, and a toroidal magnet 150 supported by a short cylindrical tubular appendix 154 extending from wall 133 towards wall 132.

Appendixes 154 communicate externally of casing 103.

Loudspeakers 145 are located side by side, and define, inside chamber 129, a chamber 129a (shown by the dotted line in Figures 4 and 5) defined by cones 147, by wall 132 facing cones 147, by portions 135a, 136a of lateral walls 135, 136 adjacent to wall 132, and by portions (not shown) of the front and rear walls.

Chamber 129a and conduit 142 define a Helmholtz resonator, the resonance frequency of which is defined by the size of chamber 129a and by the length and opening of conduit 142.

Variation 1b in Figure 5 differs from the Figure 4 muffler by cylindrical wall 107 presenting a number of through cooling holes 123 enabling chamber 121 to communicate externally of casing 105.

Muffler 1c in Figure 6 differs from 1a in Figure 4 by presenting no wall 112, and by pipe 126 penetrating inside chamber 121 through an opening 180 and without contacting casing 105. In this variation, pipe 126, not being supported by casing

105, must be fitted to the underside (not shown) of the vehicle.

Figure 7 shows an example of mufflers 1a, 1b or 1c applied to an electronic system for actively reducing the noise produced by the engine.

Muffler 1a, 1b, 1c may be used to advantage in electronic systems (not described) other than the one in Figure 7, which is shown purely by way of example.

In the Figure 7 example, muffler 1a, 1b, 1c is connected to the exhaust system 160 of a vehicle (not shown), comprising an exhaust pipe 161 extending between the exhaust manifold 163 of an internal combustion engine 165 and muffler 1a, 1b, 1c.

Exhaust system 160 also comprises a catalytic converter 167 and a passive muffler 168 located in series along exhaust pipe 61, upstream from muffler 1a, 1b, 1c.

Muffler 1a, 1b, 1c is connected to an electronic noise reducing system wherein a known electronic control unit 169 is input connected to a sync sensor 170 of engine 165, and to a vibration sensor 174 (e.g. a microphone) located along pipe 161, between converter 167 and muffler 168.

Control unit 169 is also supplied with a signal from a vibration sensor 177 (e.g. a microphone) in the outflow pipe 118 of muffler 1a, 1b, 1c.

Control unit 169 comprises a final power stage 178 for supplying loudspeakers 145 of muffler 1a, 1b, 1c over line 179.

In actual use, in response to the signals from sensors 170 and 174, control unit 169 generates a signal for driving loudspeakers 145 which produce an antivibration a(t) in phase opposition to the vibration n(t) produced by engine 165.

With special reference to Figures 4-6, antivibration a(t) is generated in chamber 129 which acts as a resonator for a given spectrum of antivibration a(t) frequencies.

The antivibration a(t) produced by loudspeakers 145 is thus resonance amplified, and the antivibration a(t) generated in chamber 129 travels along conduit 142 into chamber 121 where it interacts with the vibration n(t) from pipe 126.

More specifically, vibrations a(t) and n(t) are added inside chamber 121, close to truncated-cone-shaped wall 115, and the residual vibration r(t) = n(t) + a(t) issues from outflow pipe 118 and is detected by sensor 177.

Sensor 177 supplies control unit 169 with a feedback signal proportional to the amplitude of residual vibration r(t), and on the basis of which the drive signal of loudspeakers 145 is closed-loop modified to maximize interference between antivibration a(t) and vibration n(t).

Mufflers 1a, 1b, 1c clearly provide, therefore, for reducing the temperature of loudspeakers 145.

The chamber 129 housing loudspeakers 145, in fact, is both physically and thermally separated by conduit 142 and sheet 157 from the chamber 121 into which the exhaust gas produced by engine 165 is fed directly, so that the temperature inside chamber 129 is lower than in chamber 121.

Moreover, magnets 150 are subjected to and dynamically cooled by the air flowing about muffler 1a, 1b, 1c and into appendixes 154 when the vehicle (not shown) is in motion.

Holes 123 or opening 180 (Figure 6) provide, by the Venturi effect, for drawing air into chamber 121, and so reducing the temperature inside chamber 121 and hence of the muffler as a whole.

Muffler 1a, 1b, 1c also provides for excellent active attenuation (loudspeakers supplied) and fairly good passive attenuation (loudspeakers not supplied) of the vibration n(t) produced by engine 165.

In fact, resonance amplifying antivibration a(t) provides for enhancing interference and so achieving a greater reduction in vibration n(t).

In the event electronic control unit 169 is disabled (or breaks down), antivibration a(t) is no longer generated.

In which case, casing 103 and conduit 142 act as a Helmholtz resonator which is energized by the vibration n(t) generated by the engine. Vibration n(t) therefore travels along conduit 142 into chamber 129a, and oscillates the air inside chamber 129a so that the energy of vibration n(t) is partly dissipated in the form of heat, and muffler 1a, 1b, 1c provides for fairly good passive attenuation of the vibration n(t) generated by the engine.

Claims

1. An active exhaust gas muffler comprising:
   - an outer casing (3) defining at least one inner cavity (8; 121) communicating with a gas inflow pipe (32; 126) and a gas outflow pipe (38; 118); and
   - at least one transducer (6; 145) for generating a vibration a(t) directed into said cavity (8; 121);

   characterized in that it comprises means (13; 157, 123, M) for reducing the temperature of at least part of said transducer (6; 145).

2. A muffler as claimed in Claim 1, characterized in that said temperature reducing means comprise at least a partition (13) impervious to heat fitted to said casing (3);

   said partition (13) defining, inside the casing, a first chamber (8a) and a second chamber (8b);

   said first chamber (8a) at least partially housing said transducer (6); and said second chamber (8b) communicating with said gas inflow pipe (32) and with said gas outflow pipe (38).

3. A muffler as claimed in Claim 2, characterized in that said second chamber (8b) at least partially houses a passive muffler (35).

4. A muffler as claimed in Claim 2 or 3, characterized in that said partition (13) presents a central opening (19);

said transducer (6) comprising a loudspeaker, the cone of which presents a peripheral edge facing the peripheral edge of said opening (19).

5. A muffler as claimed in Claim 4, characterized in that said central opening (19) is closed by barrier means (M) permeable to sound vibration and substantially impervious to heat.

6. A muffler as claimed in one of the foregoing Claims from 2 to 5, wherein said transducer (6) comprises a loudspeaker presenting a permanent magnet (26), in particular a cylindrical permanent magnet (26); characterized in that said casing (3) presents at least a through opening (21); and said magnet (26) engages said through opening (21) and is located at least partially outside the casing (3).

7. An active exhaust gas muffler as claimed in Claim 1, characterized in that it comprises a first hollow body (103) defining a third inner chamber (129, 129a) communicating with said gas inflow pipe (126) via at least a connecting opening (142) and housing at least one vibration transducer (145); and said first body (103) is located to the side of said inflow pipe (126).

8. A muffler as claimed in Claim 7, characterized in that said third chamber (129, 129a) and said connecting opening (142) are so sized as to define a resonator, in particular a Helmholtz resonator, oscillating at at least one of the vibration n(t) frequencies produced by the engine (165) generating said exhaust gas.

9. A muffler as claimed in Claim 8, characterized in that said third chamber (129, 129a) is defined by inner walls (132, 135a, 136a) of said first body (103), and by at least a movable portion (147) of said transducer (145).

10. A muffler as claimed in any one of the foregoing Claims from 7 to 9, characterized in that it comprises a hollow elongated second body (105) defining a fourth chamber (121) communicating at the inlet with said gas inflow pipe (126) and communicating with at least a gas outflow pipe (118);

said third chamber (129, 129a) being located to the side of said fourth chamber (121) and communicating with said fourth chamber (121) via a tubular conduit (140) extending between said first (103) and second (105) bodies.

11. A muffler as claimed in Claim 10, characterized in that said temperature reducing means comprise at least a cooling opening (123; 180) in the wall (107) of said second body (105);

said cooling opening (123; 180) permitting said fourth chamber (121) to communicate externally of the muffler, and permitting air intake into the fourth chamber (121).

12. A muffler as claimed in any one of the foregoing Claims from 7 to 11, characterized in that said temperature reducing means comprise at least a sheet (157) of material permeable to sound vibration and impervious to heat, and which is placed so as to close said connecting opening (142).

13. A muffler as claimed in any one of the foregoing Claims from 10 to 12, characterized in that said second body (105) comprises a substantially cylindrical tubular wall (107) closed by two opposite end walls (112, 115) from which said gas inflow pipe (126) and said gas outflow pipe (118) extend axially.

14. A muffler as claimed in any one of the foregoing Claims, characterized in that it comprises a cylindrical tubular body (77a) extending radially from said gas outflow pipe (38) and housing vibration detecting means (77).

15. A muffler as claimed in any one of the foregoing Claims, characterized in that said means (13) for reducing the temperature of at least part of said transducer (6) comprise at least a cooling opening formed in said casing (3) and communicating with said inner cavity (8);

said cooling opening permitting air intake into said inner cavity (8).

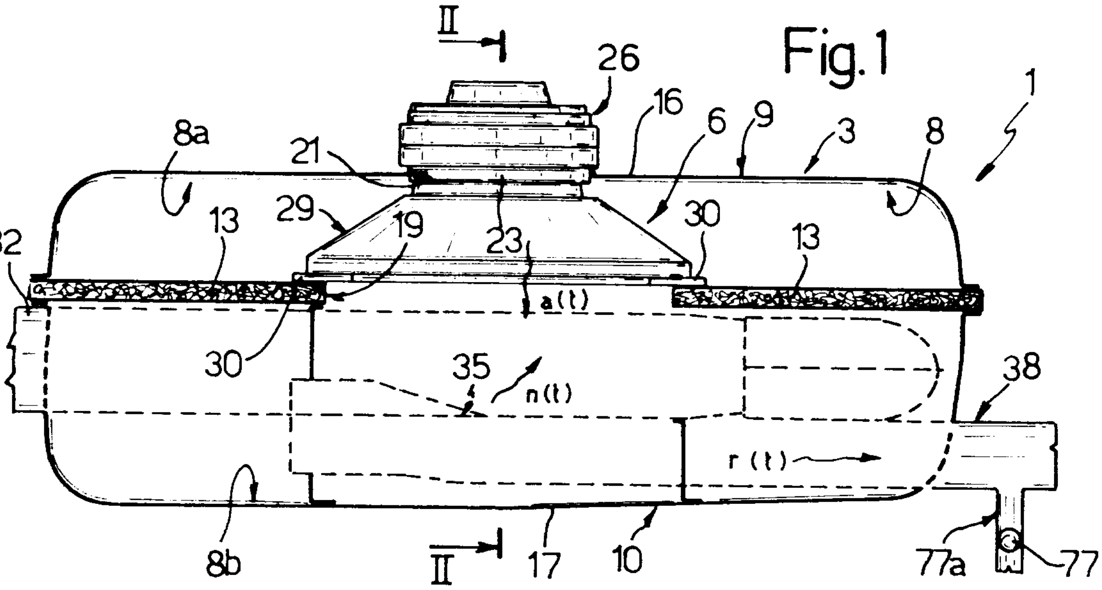


Fig.1

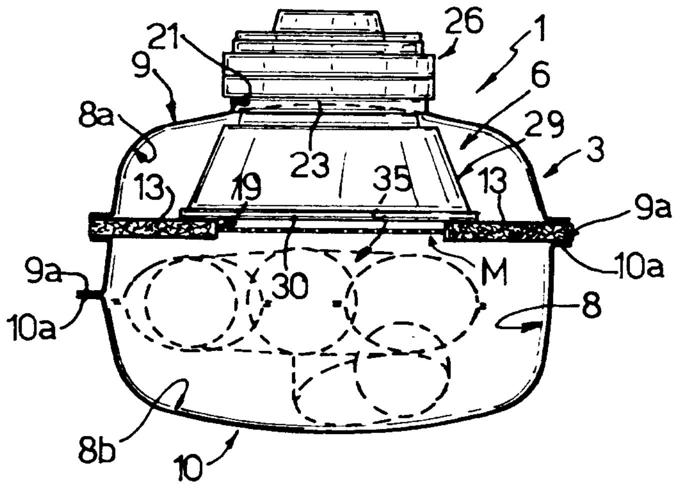


Fig.2

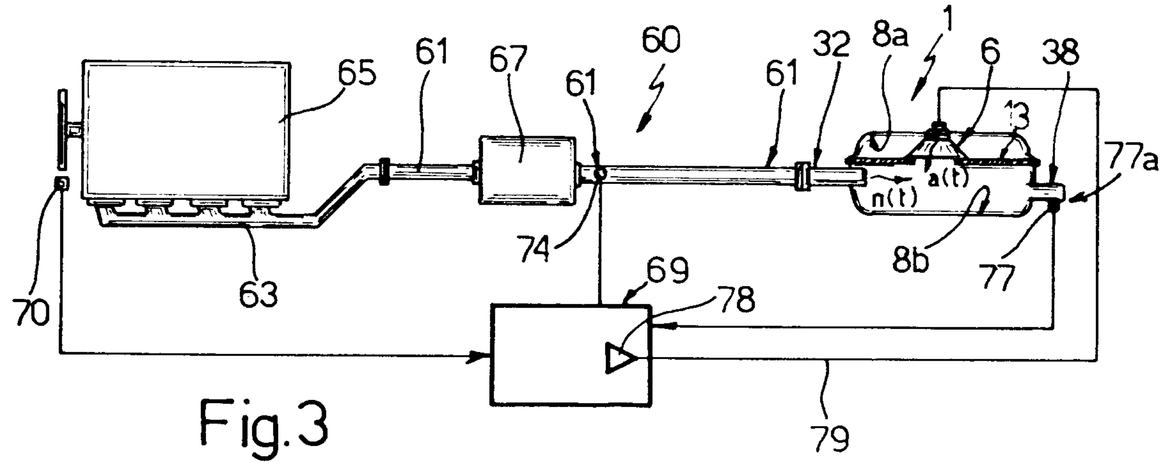
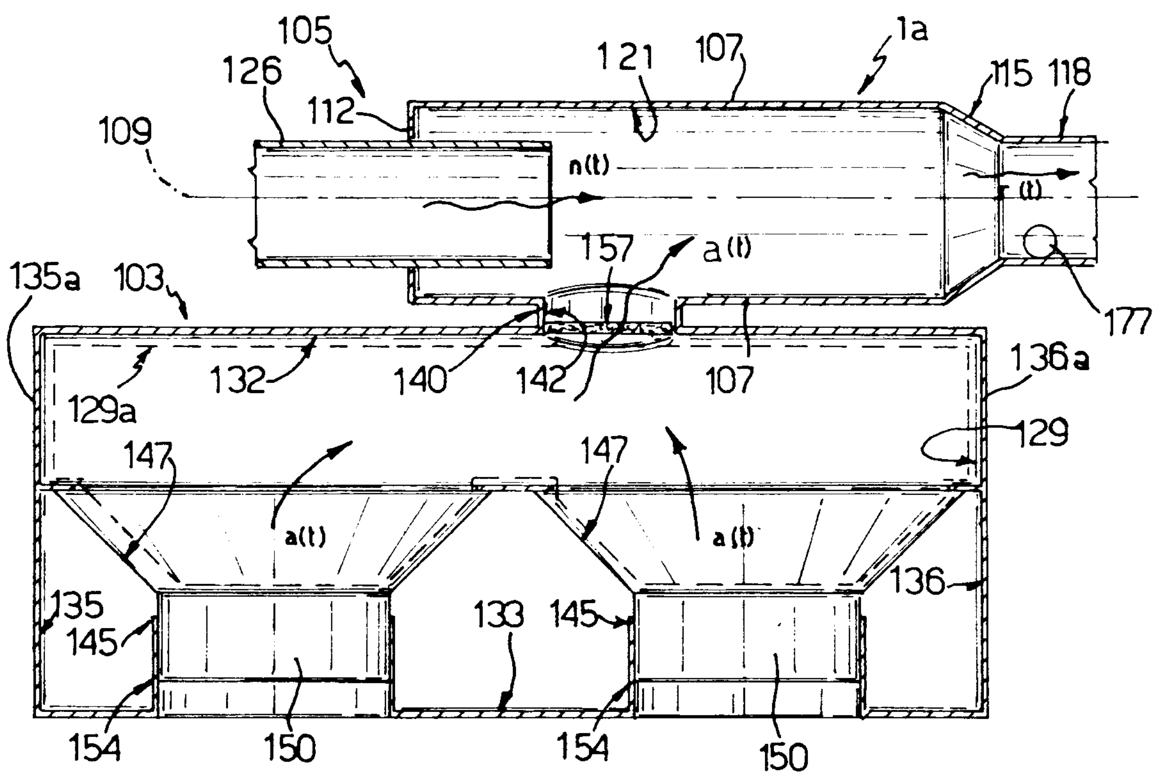


Fig.3


105
126
112
1 21
107
1a
115
118
109
n(t)
r(t)
157
a(t)
135a
103
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132
140
142
107
136a
129a
129
147
147
a(t)
a(t)
135
136
145
133
145
154
150
154
150

Fig.4

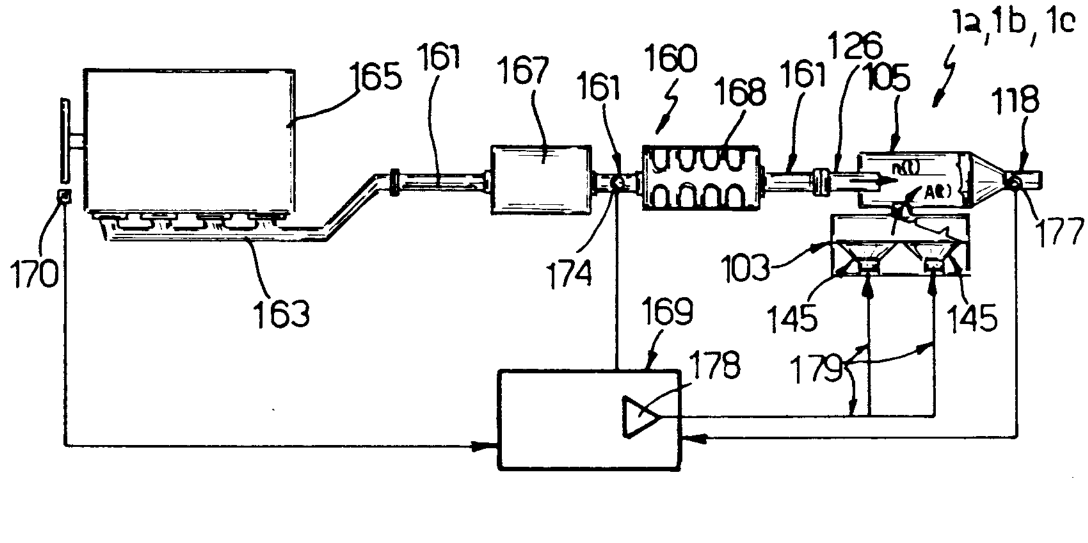
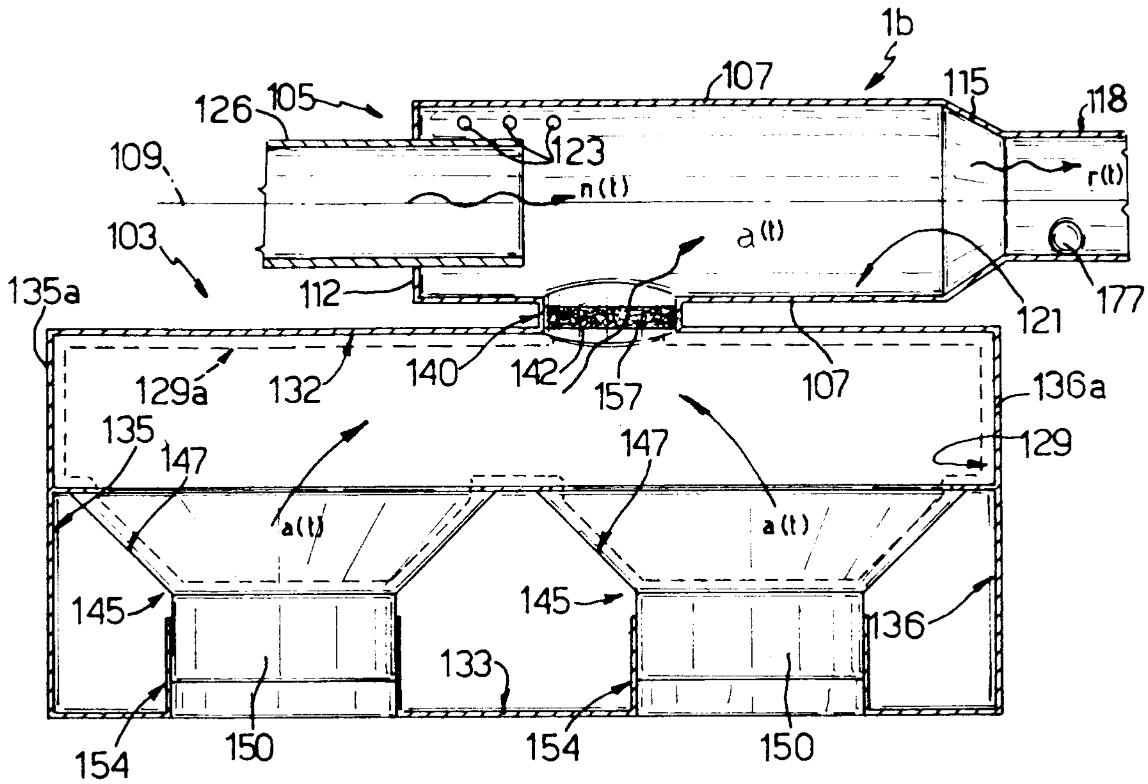

165
161
167
161
160
168
161
126
105
1a, 1b, 1c
118
n(t)
A(t)
177
170
174
103
163
145
145
169
178
179

Fig.7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r(t)
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157
107
129a
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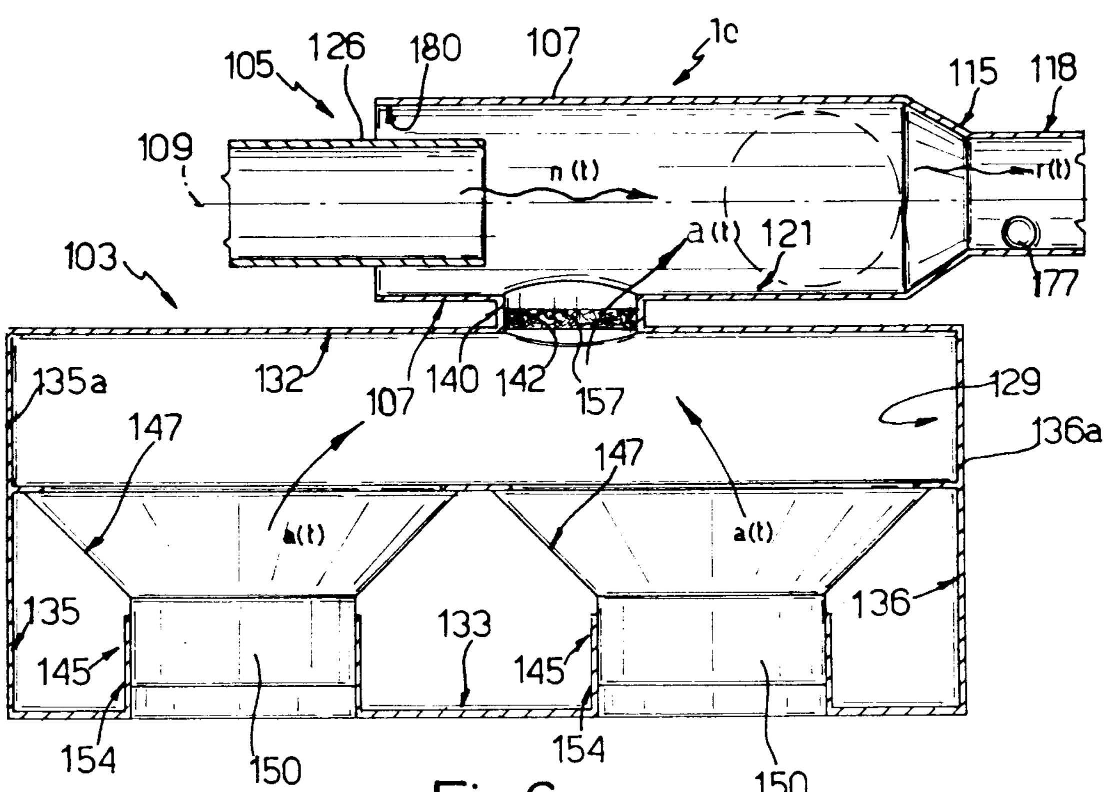
154
154

Fig.5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135a
132
107
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147
147
136a
a(t)
a(t)
135
136
145
133
145
154
150
154
150

Fig.6

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 95 10 2257

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
X Y A	WO-A-91 15666 (ACTIVE NOISE AND VIBRATION TECHNOLOGIES) * page 9, line 26 - page 11, line 24 * * page 14, line 14 - line 28; figures * ---	1-3,6 4,5,7,15 14	F01N1/06 G10K11/178
Y	PATENT ABSTRACTS OF JAPAN vol. 17 no. 263 (M-1415) ,24 May 1993 & JP-A-05 001811 (MITSUBISHI) 8 January 1993, * abstract * ---	4,5	
Y	WO-A-93 05282 (ACTIVE NOISE AND VIBRATION TECHNOLOGIES) * page 11, line 6 - line 18; figures * ---	7	
Y	WO-A-93 09334 (NOISE CANCELLATION TECHNOLOGIES) * abstract; figure 1 * ---	15	
A	PATENT ABSTRACTS OF JAPAN vol. 18 no. 21 (P-1674) ,13 January 1994 & JP-A-05 257483 (NKK CORP) 8 October 1993, * abstract * -----		TECHNICAL FIELDS SEARCHED (Int.Cl.6) F01N G10K

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	15 May 1995	Sideris, M

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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