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(54) **Title:** AN EXHAUST GAS NOISE ATTENUATOR UNIT FOR INTERNAL COMBUSTION PISTON ENGINE

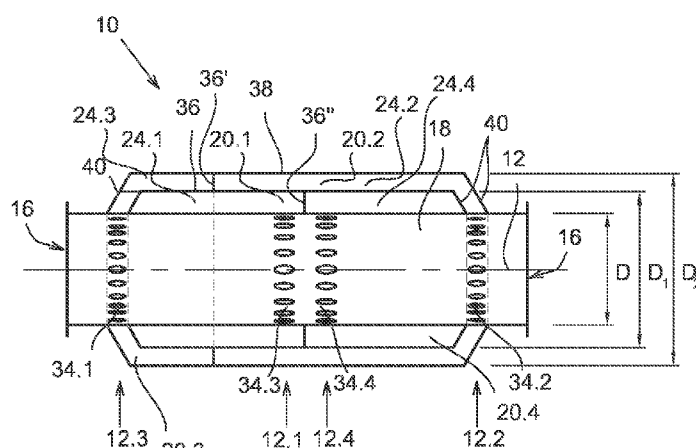


Fig. 2

(57) **Abstract:** Invention relates to an exhaust gas noise attenuator unit (10), the attenuator unit comprising exhaust gas inlet and an exhaust gas outlet (16) arranged in flow connection with each other via a duct section (18) between them; at least two attenuation chambers (20.1, 20.2, 20.3, 20.4) arranged in flow connection with the duct section (18); at least two attenuation chambers are reactive attenuation chambers with open gas space; and the spaces thereof are at least partially bordered by a common wall section (36, 36'), and a first one (20.1) of the at least two attenuation chambers is arranged in flow connection with the duct section (18) at a first location (12.1) in longitudinal direction; and a second one (20.2) of the at least two attenuation chambers is arranged in flow connection with the duct section (18) at a second location (12.2) in longitudinal direction.



An exhaust gas noise attenuator unit for internal combustion piston engine

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Technical field

[0001] Invention relates to an exhaust gas noise attenuator unit for internal combustion piston engine according to preamble of claim 1 comprising exhaust gas inlet and an exhaust gas outlet arranged in flow connection with each other via a duct section between them, and at least two attenuation chambers arranged in flow connection with the duct section.

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Background art

[0002] Piston engines produce considerably loud noise in connection with their exhaust gas. Noise emitted through exhaust gas system of a piston engine is at least a nuisance and in most cases also harmful to environment. Therefore it is known as such to use different kinds of silencers in the exhaust gas systems.

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[0003] It is known that noise from an exhaust system of a combustion engine may be reduced by use of different types of damping techniques. A type of attenuator is a reactive attenuator. Reactive silencers generally consist duct section or a like that interconnect with a number of larger chambers. The noise reduction mechanism of reactive silencer is that the area discontinuity provides an impedance mismatch for the noise wave traveling along the duct. This impedance mismatch results in a reflection of part of the noise wave back toward the source or back and forth among the chambers. The reflective effect of the silencer chambers and ducts (typically referred to as resonators) essentially prevents some noise wave elements from being transmitted past the silencer. The reactive silencers are more effective at lower frequencies than at high frequencies, and are most widely used to attenuate the exhaust noise of internal combustion engines.

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[0004] Another type of attenuator is a resistive attenuator. Such an attenuator contains typically fibrous or porous noise-absorbing materials. Attenuation of noise is based on converting the noise energy into heat caused by friction in the voids between the oscillating gas particles and the fibrous or porous noise-absorbing material. Such a noise attenuator intended for a ventilation system is described in the patent document GB 2 122 256. As absorbent, there is usually used mineral wool or glass wool included some adhesive, which causes the absorbent to have a bonded structure. A gas-permeable surface layer, such as a perforated plate, may also protect the absorbent. Such a resistive attenuator will have a noise-attenuating property, which covers a wide frequency range and is dependent, besides on the thickness and rate of flow of the absorbent, also on the length and the inner area of the attenuator.

[0005] It is also known to arrange both reactive and resistive elements into same attenuator unit. An example of such an element is described in US 4 371 054. Also in EP 1704306 B1 there is shown an attenuating unit in which two reactive parts and a resistive part may be fitted into one unit. In EP 0958449 B1 there is disclosed a device for noise reduction in which plurality of interconnected part form a module in which there is at least one resistive attenuator and at least one reactive attenuator.

[0006] Particular in applications where only limited space is available the size of such silences is of great importance. For example in marine vessels such as ships the routing of ducts of the exhaust gas system from engine room to the outside of the vessel includes sections where available space is extremely restricted.

[0007] It is an object of the invention to provide an exhaust gas noise attenuator unit for an internal combustion piston engine to reduce exhaust gas noise originating from an internal combustion piston engine, which solves at least one of the above mentioned problems of prior art.

[0008] It is a particular object of the invention to provide an exhaust gas noise attenuator unit for an internal combustion piston engine in a marine vessel which provides better prospects to lead an exhaust gas ducting from a machine room to the outside of the vessel.

Disclosure of the Invention

[0009] Objects of the invention are met by an exhaust gas noise attenuator unit, the attenuator unit comprising exhaust gas inlet and an exhaust gas outlet
5 arranged in flow connection with each other via a duct section between them, and at least two attenuation chambers arranged in flow connection with the duct section. It is characteristic to the invention that at least two attenuation chambers are reactive attenuation chambers with open gas space, the spaces thereof are at least partially bordered by a common wall section, a first one of the at least two
10 attenuation chambers is arranged in flow connection with the duct section at a first location in longitudinal direction, and a second one of the at least two attenuation chambers is arranged in flow connection with the duct section at a second location in longitudinal direction.

[0010] According to an embodiment of the invention the duct section is substantially straight between the inlet and the outlet.
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[0011] According to an embodiment of the invention the attenuation chamber and the flow connection via which the attenuation chamber is connected to the duct section has equal and constant cross sectional area.

[0012] According to an embodiment of the invention the at least two attenuation chambers are arranged coaxially with each other.
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[0013] According to an embodiment of the invention the first and the second attenuation chamber extend in a direction of the longitudinal center axis of the unit.

[0014] According to an embodiment of the invention the unit comprises at least three chambers and at least one attenuation chamber is arranged at least partially
25 overlapping with two other attenuation chambers in longitudinal direction.

[0015] According to an embodiment of the invention the chambers have annular cross section.

[0016] According to an embodiment of the invention the longitudinal walls of the unit are coaxial to each other.

[0017] According to an embodiment of the invention the cross sectional area of the duct section substantially equals to the cross sectional area of the first attenuation chamber and the second attenuation chamber.

[0018] According to an embodiment of the invention the duct section has a diameter of D , the first attenuation chamber has an diameter of $1,3 - 1,5 \times D$ and the second attenuation chamber is at least partially enclosing the first chamber has an diameter of $1,6 - 1,8 \times D$.

10 [0019] According to a specific embodiment of the invention the duct section has a diameter of D , the first attenuation chamber has an diameter of $1,41 \times D$ and the second attenuation chamber is at least partially enclosing the first chamber has an diameter of $1,73 \times D$.

15 [0020] According to an embodiment of the invention each of the chambers consists of a longitudinally extending single space at one average radial distance from the longitudinal center axis of the unit.

[0021] According to an embodiment of the invention each of the chambers consists of a longitudinally extending single annular space having a constant average diameter.

20 [0022] According to an embodiment of the invention the unit comprises a resistive attenuator section enclosed by at least two reactive attenuation chambers.

[0023] According to an embodiment of the invention the resistive attenuator section is arranged in annular space between the duct section and the intermediate wall, and the reactive attenuation chambers are arranged between the intermediate wall and the outer wall.

25 [0024] According to an embodiment of the invention the resistive attenuator section is arranged longitudinally between two reactive attenuator chambers.

[0025] By means of the invention it is possible to arrange more the exhaust gas noise attenuation chamber to a shorter length of an exhaust gas duct while majority of the duct has a normal, required diameter. This way the noise attenuators unit or units are in a marine vessel preferably arranged nearer the engine where space is available and the duct led through e.g. a funnel without radial extensions consuming less space. Thus the noise attenuator unit according to the invention is suitable to be used in connection with large, high power piston engines installed in a marine vessel.

10 Brief Description of Drawings

[0026] In the following, the invention will be described with reference to the accompanying exemplary, schematic drawings, in which
Figure 1 illustrates an exhaust gas noise attenuator unit according to an embodiment of the invention,
Figure 2 illustrates an exhaust gas noise attenuator unit according to another embodiment of the invention,
Figure 3 illustrates an exhaust gas noise attenuator unit according to another embodiment of the invention,
Figure 4 illustrates an exhaust gas noise attenuator unit according to another embodiment of the invention, and
Figure 5 illustrates an exhaust gas noise attenuator unit according to another embodiment of the invention.

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Detailed Description of Drawings

[0027] Figure 1 depicts schematically a noise attenuator unit 10 according to an embodiment of the invention. The unit has a cross section 14 which is symmetrical to its longitudinal center axis 12. In the embodiment of figure 1 the cross section is circular for all wall sections of the unit which is a preferred embodiment, but it may also be symmetrically e.g. rectangular. The unit comprises openings 16 at the opposite ends of the unit serving as exhaust gas inlet and an exhaust gas outlet. The

inlet and the outlet may be provided with a flange or alike to attach the unit to an exhaust duct. The openings 16 are arranged at opposite ends of a duct section 18 symmetrically in respect to a common longitudinal center axis 12. Advantageously the duct section 18 between the inlet and the outlet is straight and the internal volume forms direct passage and substantially unrestricted flow between the openings 16. However, the wall of the duct section 18 comprises one or more openings 34.1. 34.2.

[0028] The attenuator unit comprises at least two attenuation chambers 20.1, 20.2. The chambers 20.1, 20.2 are arranged coaxially to each other and they extend in a direction of the longitudinal center axis 12 parallel with each other and the duct section 18.

[0029] In the embodiment of figure 1 each of the chambers consists of a single space 24.1 longitudinally extending single annular space at one average radial distance from the longitudinal center axis 12 of the unit 10. The space, when being annular space is substantially having a constant average diameter, 24.2 formed by two opposing gas tight cylindrical bordering walls 36, 38 having different diameters. The cylindrical bordering wall 36 is a common wall section between the chambers 20.1, 20.2 which also extend in the longitudinal direction of the center axis 12. The spaces in the chambers are open gas spaces, so that the space may be freely filled with the exhaust gas. The cylindrical walls are provided with radially extending end walls 40 between the duct section 18 and the ends of the cylindrical wall 36, 38. The first and the second cylindrical bordering wall may be provided with common or separate end walls 40 in which case both of the cylindrical walls are joined to the end wall. Thus the space 24.2 between the cylindrical walls 36, 38 is in connection with the duct section 18 between the end walls 40. Preferably the cross sectional area formed by the end walls equals to the cross sectional area of the space 24.2. Thus, the space 24.2 and its flow connection with the duct section 18 is arranged to operate as a so called quarter-wave resonator. At the end, where the outer space 24.1 is in connection with the duct section 18 the first and the second cylindrical bordering wall are provided with separate end walls 40 for the inner and the outer bordering wall. The space between the end walls form an annularly and/or radially extending connection path between the duct section 18

and the outer space 24.2. The annular spaces 24.1, 24.2 are here bordered by a common wall section 36 between the spaces. The chambers are arranged coaxially to the duct section 18, thus both of the chambers surround the duct section 18 over a length thereof.

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[0030] Each of the chambers are in flow connection with the duct 18 at one longitudinal location. The first chamber 20.1 is in flow connection with the duct 18 at a first longitudinal location 12.1 and the second chamber 20.2 is in flow connection with the duct 18 at a second longitudinal location 12.2. The first and the second longitudinal locations are at a distance from each other, near the ends of the unit. In this embodiment the flow connection between the chamber and the duct is arranged by means of the one or more openings 34.1, 34.2. Here the openings are arranged along the wall of the duct section 18 to circumscribe the duct section. The openings provide communication between the duct and the chamber so that the chamber operates as a reactive attenuation chamber in a manner known as such. The openings and thus the flow connection is arranged at the opposite ends of the each chamber 20.1, 20.2.

[0031] In the embodiment of figure 1 the first chamber 20.1 encloses the duct section 18 and the second chamber 20.2 encloses the first chamber 20.1. The duct section has an inner diameter D , the first chamber has a diameter D_1 and the second chamber has a diameter D_2 . The first chamber has an annular cross section between diameters $D - D_1$ and the second chamber has an annular cross section between diameters $D_1 - D_2$. According to an embodiment of the invention the diameter of the first chamber $D_1 = 1,3 - 1,5 \times D$ and the diameter of the second chamber $D_2 = 1,6 - 1,8 \times D$.

[0032] According to an advantageous embodiment of the invention the diameter of the first chamber $D_1 = 1,41 \times D$ and the diameter of the second chamber $D_2 = 1,73 \times D$. This way the annular cross sections of the first and the second chambers have an area substantially equal to the area of the duct section 18.

[0033] Figure 2 depicts schematically a noise attenuator unit 10 according to another embodiment of the invention. Like the embodiment of figure 1 the unit com-

prises openings 16 at the opposite ends of the unit serving as exhaust gas inlet and an exhaust gas outlet. The openings 16 are arranged at opposite ends of a duct section 18 symmetrically in respect to a common longitudinal center axis 12. The duct section 18 between the inlet and the outlet is straight and the internal volume forms direct passage and substantially unrestricted flow between the openings 16. However, the wall of the duct section 18 comprises openings 34.1, 34.2, 34.3 34.4 providing a flow communication between the duct section and the attenuation chambers arranged on the duct section. In this embodiment the attenuator unit comprises four attenuation chambers 20.1, 20.2, 20.3, 20.4. Two of the chambers 20.1, 20.4, inner chambers, are arranged to enclose the duct section 18 and two of the chambers 20.2, 20.3, outer chambers are arranged to enclose the inner chambers. The chambers 20.1, 20.2, 20.3, 20.4 are arranged to extend in a direction of the longitudinal center axis 12 parallel with each other and the duct section 18. Each of the chambers consists of a single annular space 24.1, 24.2, 24.3, 24.4 substantially having constant average diameter, formed by two adjacent gas tight cylindrical bordering walls 36, 38 having different diameters. The spaces are open gas spaces, so that they may be freely filled with the exhaust gas. The cylindrical walls are provided with radially extending end walls 40 between the duct section 18 and the ends of the cylindrical wall 36, 38 similarly to those shown in figure 1. The annular spaces 24.1, 24.4 and 24.3, 24.2 are here bordered by a common wall section 36 between the spaces. Additionally, the annular spaces 24.2, 24.3 and 24.1, 24.4 are here bordered by a common radial wall section 36', 36'' between the spaces. The radial wall sections 36' and 36'' are at different longitudinal location so that the length of the gas spaces is different. This way each cylindrical wall 36, 38 borders two separate, successive annular chambers in longitudinal direction. In this embodiment at least one attenuation chamber is arranged overlapping with two other attenuation chambers at least partially in longitudinal direction.

[0034] Each of the chambers are in flow connection with the duct 18 at one longitudinal location, thus the first chamber 20.1 is in flow connection with the duct 18 at a first longitudinal location 12.1, the second chamber 20.2 is in flow connection with the duct 18 at a second longitudinal location 12.2, the third chamber 20.3 is in flow connection with the duct 18 at a third longitudinal location 12.3, and the

fourth chamber 20.4 is in flow connection with the duct 18 at a fourth longitudinal location 12.4. Also in this embodiment the flow connection between the chamber and the duct is arranged by means of the one or more openings 34.1, 34.2, 34.3, 34.4.

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[0035] In the embodiment of figure 2 the cylindrical walls 36, 38 are so arranged that the diameter of the first wall $D_1 = 1,4 \times D$ and the diameter of the wall chamber $D_2 = 1,73 \times D$. This way the respective annular cross sections have an area substantially equal to the area of the duct section 18.

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[0036] In figure 3 there is shown an embodiment which is otherwise similar to that in figure 2 except that the locations 12.1, 12.4 of the flow connections through the openings 34.3 and 34.4 are at the opposite ends of the unit.

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[0037] Figure 4 shows an embodiment of the attenuator unit 10 in which a first and a second reactive attenuator chambers 20.1, 20.2 arranged and operating similarly to the third and the second attenuator chambers 20.3, 20.2 in the figure 2 having the flow connections 12.1, 12.2 at the opposite ends of the unit. Thus here the first and a second reactive attenuator chambers 20.1, 20.2 are arranged between the intermediate wall 36 and the outer wall 38 that is, to the outer space. In this embodiment the annular space 42 between the intermediate wall 36 and the duct section 18 is provided with a resistive attenuator section 45 comprising a filling material 44 inside the space and at least partial perforation 46 in the wall of the duct section 18 in the region of the annular space 42. The resistive attenuator section 45 is enclosed by two reactive attenuator chambers 20.1, 20.2 arranged successively around the space 42 so that the chambers are in flow connection with the duct section 18 at the opposite ends of the unit 10. Additionally, the annular spaces 24.1 and 24.2 of the chambers 20.1, 20.2 are here bordered by a common radial wall section 36' between the spaces. At the ends of the unit 10 the outer spaces 24.1 and 24.2 are in connection with the duct section 18 via a connection path between separate end walls 40 for the inner and the outer bordering wall 36, 38. The space between the end walls 40 form an annularly and/or radially extending connection path between the duct section 18 and the outer spaces 24.1, 24.2.

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[0038] Figure 5 shows an embodiment of the attenuator unit 10 in which a first and a second reactive attenuator chambers 20.1, 20.2 arranged and operating similarly to the figure 4 having the flow connections 12.1, 12.2 at the opposite ends of the unit. Thus the first and a second reactive attenuator chambers 20.1, 20.2 are arranged between the walls 36 and 38. Further the unit comprises a third and a fourth reactive attenuator chambers 20.3, 20.4 between the cylindrical wall 36 and the duct section 18. Radial wall sections 36'' are arranged to border a section longitudinally at the center region in the annular space between the intermediate wall 36 and duct section 18. In this center region there is arranged a resistive attenuator section 45 comprising a filling material 44 inside the space 42 and at least partial perforation 46 in the wall of the duct section 18 in the region of the annular space 42. The third and the fourth reactive attenuator chambers 20.3, 20.4 are in flow connection with one or more openings 34.3, 34.4. In this embodiment the resistive attenuator section 45 is enclosed by two reactive attenuator chambers 20.1, 20.2 arranged successively around the space 42 so that the chambers are in flow connection with the duct section 18 at the opposite ends of the unit 10. Additionally, the annular spaces 24.1 and 24.2 of the chambers 20.1, 20.2 are here bordered by a common radial wall section 36' between the spaces. At the ends of the unit 10 the outer spaces 24.1 and 24.2 are in connection with the duct section 18 via a connection path between separate end walls 40 for the inner and the outer bordering wall 36, 38. The space between the end walls 40 form an annularly and/or radially extending connection path between the duct section 18 and the outer spaces 24.1, 24.2. Further the annular space between the duct section 18 and the intermediate wall 36 comprises the resistive attenuator section 45 arranged longitudinally between two reactive attenuator chambers 20.3, 20.4.

[0039] While the invention has been described herein by way of examples in connection with what are, at present, considered to be the most preferred embodiments, it is to be understood that the invention is not limited to the disclosed embodiments, but is intended to cover various combinations or modifications of its features, and several other applications included within the scope of the invention, as defined in the appended claims. The details mentioned in connection with any embodiment above may be used in connection with another embodiment when such a combination is technically feasible.

Claims

1. An exhaust gas noise attenuator unit (10) for internal combustion piston engine, the attenuator unit comprising
- 5 - exhaust gas inlet and an exhaust gas outlet (16) arranged in flow connection with each other via a duct section (18) between them,
- at least two attenuation chambers (20.1, 20.2, 20.3, 20.4) arranged in flow connection with the duct section (18),
- characterized** in that
- 10 - at least two attenuation chambers are reactive attenuation chambers with open gas space,
- the spaces thereof are at least partially bordered by a common wall section (36, 36'),
- a first one (20.1) of the at least two attenuation chambers is arranged in flow
- 15 connection with the duct section (18) at a first location (12.1) in longitudinal direction, and
- a second one (20.2) of the at least two attenuation chambers is arranged in flow connection with the duct section (18) at a second location (12.2) in longitudinal direction.
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2. An exhaust gas noise attenuator unit according to claim 1, **characterized** in that the duct section (18) is substantially straight between the inlet and the outlet (16).
3. An exhaust gas noise attenuator unit according to claim 1, **characterized** in that
- 25 attenuation chamber (20.1, 20.2) and the flow connection via which the chamber is connected to the duct section has constant cross sectional area.
4. An exhaust gas noise attenuator unit according to claim 1, **characterized** in that the at least two attenuation chambers (20.1, 20.2) are arranged coaxially with
- 30 each other.
5. An exhaust gas noise attenuator unit according to anyone of the claims 1 - 4, **characterized** in that the first and the second attenuation chamber extend in a direction of the longitudinal center axis (12) of the unit.

6. An exhaust gas noise attenuator unit according to claim 1, **characterized** in that the unit comprises at least three chambers (20.1,20.2,20.3) and the at least one attenuation chamber (20.1) is arranged at least partially overlapping with two other
5 attenuation chambers (20.2, 20.3) in longitudinal direction.

7. An exhaust gas noise attenuator unit according to claim 4, **characterized** in that the chambers have annular cross section (14).

10 8. An exhaust gas noise attenuator unit according to anyone of the preceding claims 1-7, **characterized** in that the longitudinal walls of the unit are coaxial to each other.

9. An exhaust gas noise attenuator unit according to anyone of the preceding
15 claims, **characterized** in that the cross sectional area of the duct section (18) substantially equals to the cross sectional area of the first attenuation chamber (20.1) and the second attenuation chamber (20.2).

10. An exhaust gas noise attenuator unit according to claim 9, **characterized** in
20 that the duct section has a diameter of D , the first attenuation chamber has an diameter of $1,3 - 1,5 \times D$ and the second attenuation chamber is at least partially enclosing the first chamber has an diameter of $1,6 - 1,8 \times D$.

11. An exhaust gas noise attenuator unit according to claim 9, **characterized** in
25 that the duct section has a diameter of D , the first attenuation chamber has an diameter of $1,41 \times D$ and the second attenuation chamber is at least partially enclosing the first chamber has an diameter of $1,73 \times D$.

12. An exhaust gas noise attenuator unit according to claim 1 or 9, **characterized**
30 in that each of the chambers consists of a longitudinally extending single space at one average radial distance from the longitudinal center axis (12) of the unit.

13. An exhaust gas noise attenuator unit according to claim 12, **characterized** in
35 that each of the chambers consists of a longitudinally extending single annular space having a constant average diameter.

14. An exhaust gas noise attenuator unit according to claim 1, **characterized** in that the unit (10) comprises a resistive attenuator section (45) enclosed by the at least two reactive attenuation chambers (20.1, 20.2).

- 5 15. An exhaust gas noise attenuator unit according to claim 14, **characterized** in that the resistive attenuator section (45) is arranged in annular space (42) between the duct section (18) and the intermediate wall (36), and that the reactive attenuation chambers are arranged between the intermediate wall (36) and the outer wall (38).

10

16. An exhaust gas noise attenuator unit according to claim 14, **characterized** in that the resistive attenuator section (45) is arranged longitudinally between two reactive attenuator chambers (20.3, 20.4).

15

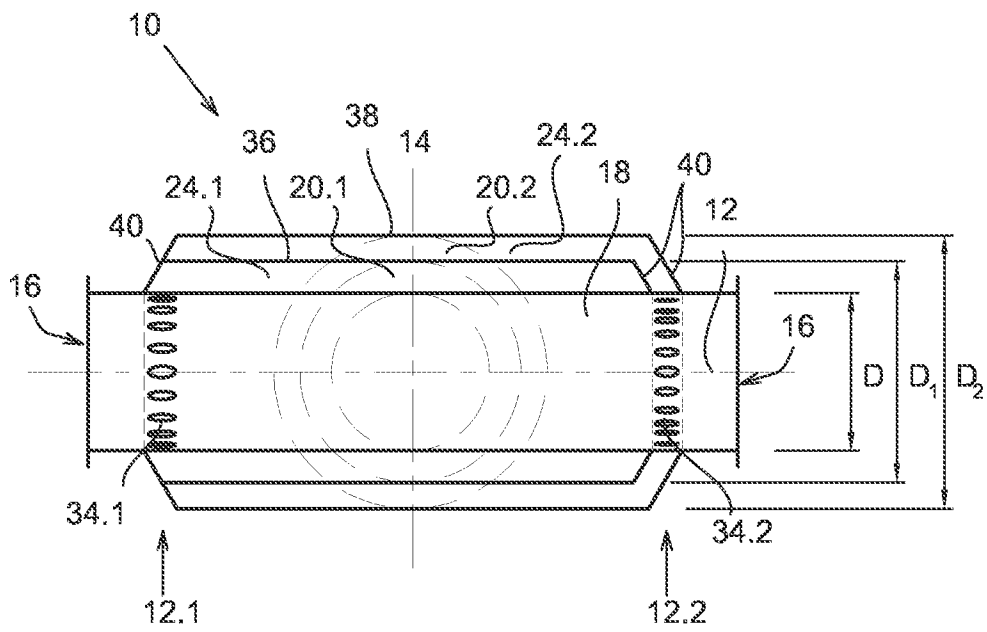


Fig. 1

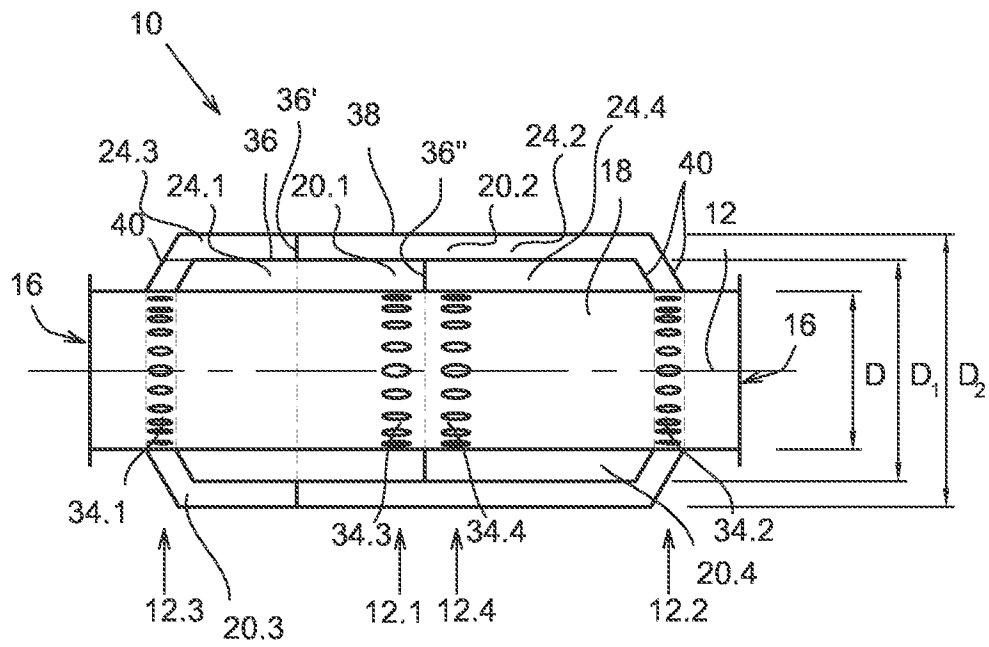


Fig. 2

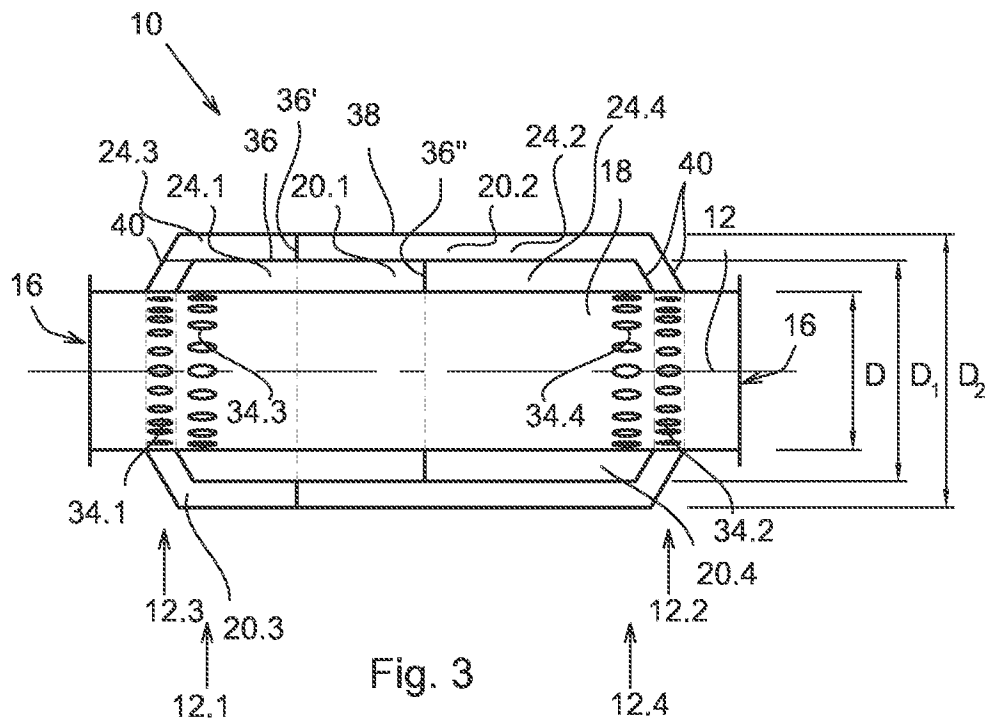


Fig. 3

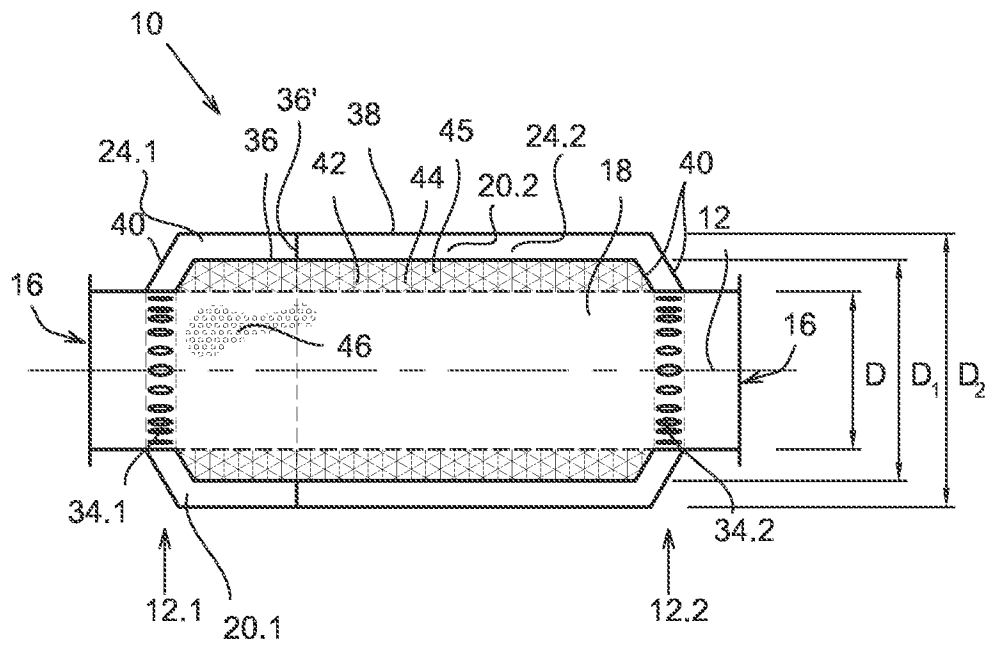


Fig. 4

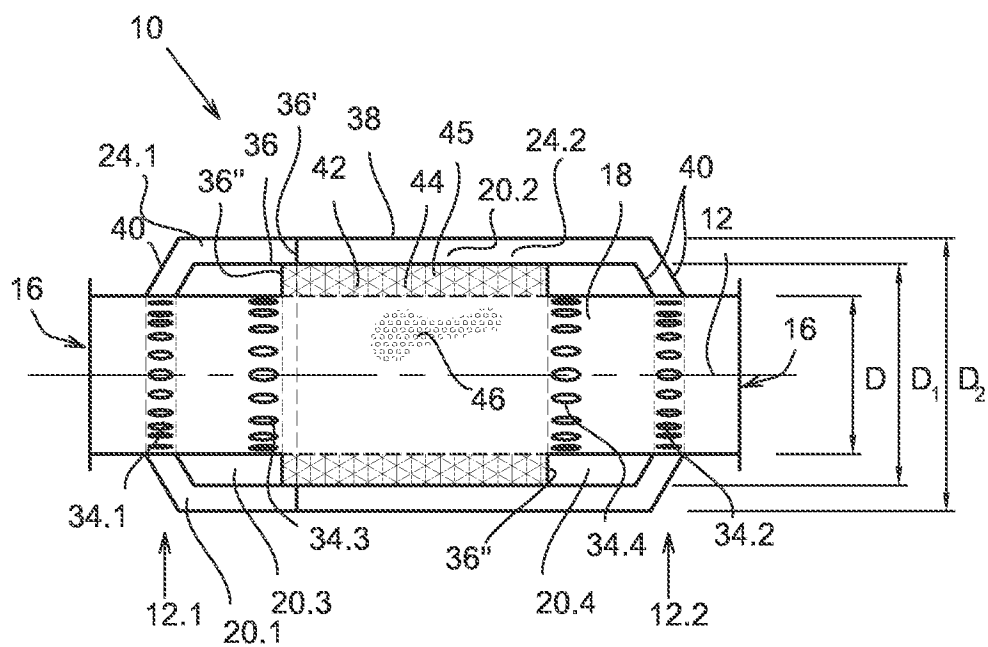


Fig. 5

INTERNATIONAL SEARCH REPORT

International application No

PCT/FI2012/051117

A. CLASSIFICATION OF SUBJECT MATTER
 INV. F01N1/02 F01N1/06
 ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
 F01N

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2005/064127 A1 (ABB AB [SE]; JOHANSSON CLAES-GOERAN [SE]; AABOM MATS [SE]) 14 July 2005 (2005-07-14)	1-3,5, 8-14,16
A	page 13, line 6 - page 15, line 2; figures 3,4	7,15
X	US 2 075 263 A (BOURNE ROLAND B) 30 March 1937 (1937-03-30)	1-3,5,6, 8-15
A	column 2, lines 11-34 column 5, lines 23-51; figures 11,12	4,7,16
X	EP 0 779 415 A1 (ABB FLAECT MARINE AB [SE] FLAECT AB [SE]) 18 June 1997 (1997-06-18)	1-5,7-13
A	column 3, line 53 - column 4, line 6; figure 4	6



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents :

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Date of the actual completion of the international search

19 July 2013

Date of mailing of the international search report

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Authorized officer

Kolland, Ulrich

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/FI2012/051117

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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