



(43) International Publication Date
26 January 2017 (26.01.2017)

- (51) International Patent Classification:
F02M 35/12 (2006.01) *F01N 1/02* (2006.01)
- (21) International Application Number:
PCT/EP2016/065117
- (22) International Filing Date:
29 June 2016 (29.06.2016)
- (25) Filing Language: English
- (26) Publication Language: English
- (30) Priority Data:
201510436110.7 23 July 2015 (23.07.2015) CN
- (71) Applicant: MANN+HUMMEL GMBH [DE/DE]; LC-IP,
Hindenburgstr. 45, 71638 Ludwigsburg (DE).
- (72) Inventors: QI, Yun; 899 Jinqiao Road, Building 35, Room
601, Shanghai, 200000 (CN). JIA, Weixin; 1728 Wulian
Road, Building 11, Room 102, Shanghai, 200135 (CN).
- (81) Designated States (unless otherwise indicated, for every
kind of national protection available): AE, AG, AL, AM,
AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY,

BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM,
DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT,
HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KN, KP, KR,
KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG,
MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM,
PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC,
SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN,
TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

- (84) Designated States (unless otherwise indicated, for every
kind of regional protection available): ARIPO (BW, GH,
GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ,
TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU,
TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE,
DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU,
LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK,
SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ,
GW, KM, ML, MR, NE, SN, TD, TG).

Published:

— with international search report (Art. 21(3))

(54) Title: SILENCER AND VEHICLE ENGINE INCLUDING SAME

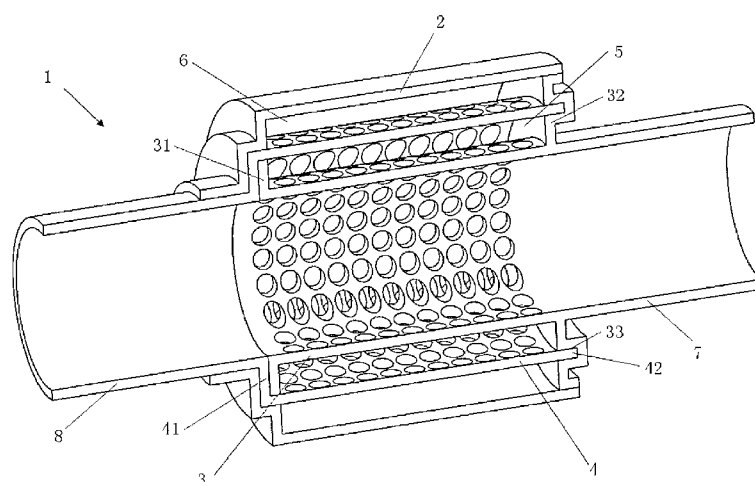


Fig. 1

(57) Abstract: The present invention discloses a silencer, including an outer housing; and a central perforated tube through which air flows. The silencer further includes an additional perforated structure located between the central perforated tube and the outer housing, a first chamber is formed between the central perforated tube and the additional perforated structure, and the additional perforated structure is configured such that at least one second chamber is formed, which is at least partially located radially outside of the first chamber, where the second chamber is communicated with the first chamber by perforates. The present invention further relates to a vehicle engine having the silencer. The silencer of the present invention is compact in structure, and has a better broad-band silencing effect.



Description**SILENCER AND VEHICLE ENGINE INCLUDING SAME****Technical Field**

The present invention relates to a silencer, which includes an outer housing and a central perforated tube through which air flows. The present invention further relates to a vehicle engine including a silencer.

Background

Small-displacement turbocharged engines are an important development in the direction of energy-efficient vehicles. A turbocharged engine improves the power and fuel economy of the vehicle, but also introduced a new problem of noise for an air inlet system, thereby severely impacting the rider's comfort of the vehicle. The howling generated by a turbocharger adopting a mechanical relief valve during instant operation belongs to typical broadband noises. A conventional silencer has a narrow silencing frequency range and cannot efficiently suppress this type of noise, and also has high cost and large size.

Perforated broadband silencers are widely applied in air inlet systems of turbocharged engines as excellent silencing elements meeting requirements of both silencing and mounting space, and each include a main tube and several annular resonance chambers. A desirable broadband silencing effect can be achieved by adjusting the width, diameter and number of the annular resonance chambers and the aperture and number of perforates.

When the perforated silencer is used in a turbocharged engine, the diameter of an air flow main tube depends on the tube diameter of the air inlet system, and the outer diameter of the annular resonance chamber is limited by the mounting space of an engine compartment. Therefore, the design of the perforated silencer having the expected silencing effect may be constrained in various terms including structure and size. Moreo-

ver, it is further required in practice that the perforated silencer has small flow loss.

However, the existing perforated silencer cannot, at times, achieve the expected silencing effect due to limitations such as the mounting space, and is complicated in structure and high in cost.

Summary

An objective of the present invention is to provide a silencer having a more compact structure and desirable broadband silencing effect and a corresponding vehicle engine.

According to a first aspect of the present invention, a silencer is provided, including: an outer housing; and a central perforated tube through which air flows; where the silencer further includes an additional perforated structure located between the central perforated tube and the outer housing; a first chamber is formed between the central perforated tube and the additional perforated structure; and the additional perforated structure is configured such that at least one second chamber is formed, which is at least partially located radially outside of the first chamber, wherein the second chamber is communicated with the first chamber by perforates.

According to an optional solution of the present invention, the additional perforated structure is configured as an additional perforated tube which is mounted over the central perforated tube.

According to an optional solution of the present invention, the additional perforated tube is disposed concentrically with the central perforated tube; and/or the additional perforated tube and/or the central perforated tube has circular cross section; and/or the first chamber and/or the second chamber has annular cross section.

According to an optional solution of the present invention, the central perforated tube is

adapted to be connected to or integrally formed with a first end pipe section located axially outside of the outer housing, and the additional perforated tube is adapted to be connected to or integrally formed with a second end pipe section located axially outside of the outer housing, wherein the first end pipe section and the second end pipe section are located at axial opposite sides of the central perforated tube.

According to an optional solution of the present invention, the second chamber is configured so as to be completely located radially outside of the first chamber; and/or the second chamber and the first chamber have the same axial length and are aligned axially with each other.

According to an optional solution of the present invention, the second chamber is configured so as to only be in a partial circumferential region of the central perforated tube.

According to an optional solution of the present invention, the second chamber is configured as a box-shaped structure which has a radially-outward opening, and the outer housing has a cover plate adapted to close the opening.

According to an optional solution of the present invention, the first chamber and/or the second chamber is separated axially into a plurality of sub-chambers, communicated with each other via a perforated member.

According to an optional solution of the present invention, the silencer is adapted for use in an air inlet system of a vehicle engine; and/or the at least one second chamber comprises a plurality of second chambers which are located radially with respect to each other, and the adjacent second chambers are communicated with each other via perforates.

According to a second aspect of the present invention, an air inlet system of a vehicle engine is provided, where the air inlet system has the silencer.

The silencer of the present invention has a compact structure and better broadband silencing effect, especially when it is used in an air inlet system of a vehicle engine, the broadband noise of the air inlet system can be obviously suppressed.

According to this invention, the silencer and the air inlet system are not limited to an engine of a vehicle but also incorporate a silencer or an air inlet system for a stationary engine, e.g. a power generator. The invention is not limited to an exhaust gas turbo charged engine but also incorporates a silencer and an air inlet system for any other engine charged by other devices like mechanical compressors or electrical driven air chargers.

Brief Description of the Drawings

The present invention will be described in more detail below with reference to the accompanying drawings, and principles, characteristics and advantages of the present invention may be better understood. The accompanying drawings include:

FIG. 1 shows a three-dimensional sectional diagram of a perforated broadband silencer according to an exemplary embodiment of the present invention;

FIG. 2 shows some simplified schematic diagrams, illustrating some possible arrangements, position relations and size relations of a first chamber and a second chamber; and

FIG. 3 shows a simplified schematic diagram of a perforated broadband silencer according to another exemplary embodiment of the present invention.

Detailed Description

In order for the technical problems to be solved, the technical solutions and beneficial technical effects of the present invention must be clear and more comprehensive. The present invention will be further described in detail through the accompanying drawings

and multiple embodiments. It should be understood that the specific embodiments described herein are merely used to explain the present invention, and are not intended to limit the protection scope of the present invention.

FIG. 1 shows a three-dimensional sectional diagram of a perforated broadband silencer according to an exemplary embodiment of the present invention.

As shown in FIG. 1, the silencer 1 mainly includes an outer housing 2, a first perforated tube 3 and a second perforated tube 4 mounted over the first perforated tube 3, where, the outer housing 2 is mounted over the second perforated tube 4. Preferably, the first perforated tube 3 is disposed concentrically with the second perforated tube 4. A first chamber 5 is formed between the first perforated tube 3 and the second perforated tube 4, and a second chamber 6 is formed between the second perforated tube 4 and the outer housing 2, so as to form two chambers communicated with each other by perforates in a radial direction relative to the air flow.

During use, an air inlet silencer is generally mounted on a main pipeline between an air cleaner and a turbocharger, or between the turbocharger and an intercooler. Preferably, the first perforated tube 3 is made to have a diameter equal to that of the main pipeline. As shown in FIG. 1, the first perforated tube 3 is integrally formed with a first end pipe section 7 extending outside of the outer housing 2; the second perforated tube 4 is also integrally formed with a second end pipe section 8 extending outside of the outer housing 2. Preferably, the first end pipe section 7, the first perforated tube 3, and the second end pipe section 8 have the same diameters, and are disposed concentrically.

During mounting, the silencer 1 is embedded into a corresponding main pipeline through the first end pipe section 7 and the second end pipe section 8, or the first end pipe section 7 and the second end pipe section 8 are integrally formed with the main pipeline.

In view of the above, the intake silencer has two chambers communicated with each other in the radial direction, and the chambers, together with perforates in the first and second perforated tubes, form a Helmholtz resonance chamber structure. When the air flow passes through the first perforated tube, the Helmholtz resonance chamber structure may generate an attenuation effect on the broadband noise. As being proved by experiments, compared with the conventional perforated silencer having only one chamber in the radial direction, the perforated silencer having multiple chambers communicated with each other in the radial direction has a better silencing effect, especially having a desirable silencing effect for any frequency in a broad frequency band. Moreover, the silencer in such configuration is compact in structure and low in cost, and can be mounted in a limited space.

It is understandable that changes of parameters such as the aperture, the percentage of perforation, the length of the perforated tube and the chamber capacity may also affect the silencing effect to some extent, and the silencer may be further optimized based on these parameters in practice.

To simplify the structure and facilitate mounting, as shown in FIG. 1, the first perforated tube 3 is provided with a first flange 31 and a second flange 32 that extend outward radially, and the second perforated tube 4 is transited to the second end pipe section 8 through a step 41. During mounting, the first flange 31 is pressed against the step 41, an end 42 of the second perforated tube 4 is embedded into a receiving groove 33 formed in the second flange 32, and the outer housing 2 is mounted over the second perforated tube 4, so that one end of the outer housing 2 is attached to the second end pipe section 8 and the step 41, and the other end is connected to the second flange 32. All portions that need to be connected may implement connection by means of, for example, soldering.

Definitely, the first flange 31 may also be omitted, that is, the end of the first perforated tube 3 is directly pressed against the step 41.

The silencer needs three members in total, being simple in structure and convenient in mounting, thereby greatly reducing the manufacturing cost.

It should be noted that the silencer 1 shown in FIG. 1 has two chambers communicated with each other in the radial direction relative to the air flow. Definitely, the number of chambers is not limited to two, and more chambers are available.

On the other hand, the silencer 1 shown in FIG. 1 is provided with two chambers communicated with each other and arranged radially in the whole circumference; however, the present invention is not limited to this arrangement. According to requirements, for example, specific limits of the mounting space, it may also be allowed that two chambers communicated with each other are provided on a part of the circumference. For example, two chambers may be disposed merely at one side of the first perforated tube 3.

For a person skilled in the art, although the first chamber 5 and the second chamber 6 shown in FIG. 1 are both annular, the first chamber and the second chamber are not limited to these criteria, and any advantageous shape may be designed according to requirements as long as the two chambers (or more chambers) are arranged radially relative to each other and communicated with each other.

According to a preferred embodiment, the second chamber may be designed as a box-shaped structure. The box-shaped structure has a radially-outward opening and a cover plate for closing the opening. The cover plate is preferably connected to the opening by snapping, thereby simplifying mounting and manufacturing processes.

Moreover, according to the technical idea of the present invention, the first chamber 5 and the second chamber 6 may also have different axial lengths, and definitely, may also have different dimensions in other directions, as long as the first chamber and the second chamber are arranged at least partially in a radial position relation relative to each other.

To better understand the technical idea of the present invention, FIG. 2 shows some simplified schematic diagrams, for illustrating some possible arrangements, position relations and size relations between the first chamber and the second chamber, where, an arrow indicates a flowing direction of the air flow passing through the first perforated tube.

In a) and b) of FIG. 2, the first chamber 5 and the second chamber 6 are partially staggered in an axial direction of flowing of the air flow, and the first chamber 5 and the second chamber 6 have different sizes. In c) of FIG. 2, the first chamber 5 is completely covered by the second chamber 6 in the axial direction, and in d) of FIG. 2, the first chamber 5 completely covers the second chamber 6 in the axial direction. In e) and f) of FIG. 2, the first chamber 5 and the second chamber 6 are partially overlapped in a radial direction relative to the air flow.

It should be noted that FIG. 2 merely shows some possible arrangement solutions, and they are not exhaustive. According to actual situations, other suitable arrangement solutions are viable, as long as the first chamber and the second chamber at least partially form a radial position relative to each other.

FIG. 3 shows a simplified schematic diagram of a perforated broadband silencer according to another exemplary embodiment of the present invention, where an arrow in-

dicates a flowing direction of an air flow passing through a first perforated tube.

As shown in FIG. 3, the first chamber 5 and the second chamber 6 are both partitioned into multiple sub-chambers by perforated partition plates 10 substantially extending radially and/or axially. Specifically, the first chamber 5 is partitioned into three sub-chambers 51, 52 and 53, and the second chamber 6 is also partitioned into three sub-chambers 61, 62 and 63. The sub-chamber 51 is axially communicated with the sub-chamber 52, and the sub-chamber 52 is also axially communicated with the sub-chamber 53. Similarly, the sub-chamber 61 is axially communicated with the sub-chamber 62, and the sub-chamber 62 is also axially communicated with the sub-chamber 63. Moreover, the sub-chamber 51 is radially communicated with the sub-chamber 61. Similarly, the sub-chamber 52 is radially communicated with the sub-chamber 62, and the sub-chamber 53 is radially communicated with the sub-chamber 63. It can be seen that the sub-chambers are communicated with one another. This structure actually can be considered a serial connection of the structure shown in FIG. 1.

For persons skilled in the art, the embodiment shown in FIG. 3 is definitely exemplary. In fact, the first chamber 5 and the second chamber 6 may also adopt other partition manners. Even some sub-chambers may be omitted according to actual requirements, and some axially adjacent sub-chambers may not be communicated with each other; all these solutions fall within the scope of the present invention.

The basic idea of the perforated silencer of the present invention lies in that multiple chambers communicated with each other and arranged at least partially in a radial position relation relative to each other are provided at least in a partial circumferential region. By means of this structure, the silencer may achieve a better broadband silencing effect.

Although the perforated silencer is described by using a silencer for an air inlet system of a vehicle engine as an example, for persons skilled in the art, the perforated silencer definitely can be applied to other scenarios that require silencing the air flow.

Specific implementation manners of the present invention are described in detail here; however, they are provided merely for explanation, and should not be construed as limiting the scope of the present invention. Various replacements, variations and modifications may be conceived without departing from the spirit and scope of the present invention.

Claims

1. Silencer, comprising:

an outer housing (2) and a central perforated tube (3) through which air flows, characterized in that the silencer (1) further comprises an additional perforated structure (4) located between the central perforated tube (3) and the outer housing (2), a first chamber (5) is formed between the central perforated tube (3) and the additional perforated structure (4), and the additional perforated structure (4) is configured such that at least one second chamber (6) is formed, which is at least partially located radially outside of the first chamber (5), wherein the second chamber (6) is communicated with the first chamber (5) by perforates.

2. Silencer as claimed in claim 1, characterized in that the additional perforated structure (4) is configured as an additional perforated tube (4) which is mounted over the central perforated tube (3).

3. Silencer as claimed in claim 2, characterized in that the additional perforated tube (4) is disposed concentrically with the central perforated tube (3) and/or the additional perforated tube (4) and/or the central perforated tube (3) have/has circular cross section and/or the first chamber (5) and/or the second chamber (6) have/has annular cross section.

4. Silencer as claimed in claim 2 or 3, characterized in that the central perforated tube (3) is adapted to be connected with or integrally formed with a first end pipe section (7) located axially outside of the outer housing (2), and the additional perforated tube (4) is adapted to be connected with or integrally formed with a second end pipe section (8) located axially outside of the outer housing (2), wherein the first end pipe section (7) and the second end pipe section (8) are located at axial opposite sides of the central

perforated tube (3).

5. Silencer as claimed in any one of the previous claims, characterized in that the second chamber (6) is configured so as to be completely located radially outside of the first chamber (5); and/or the second chamber (6) and the first chamber (5) have the same axial length and are aligned axially with each other.

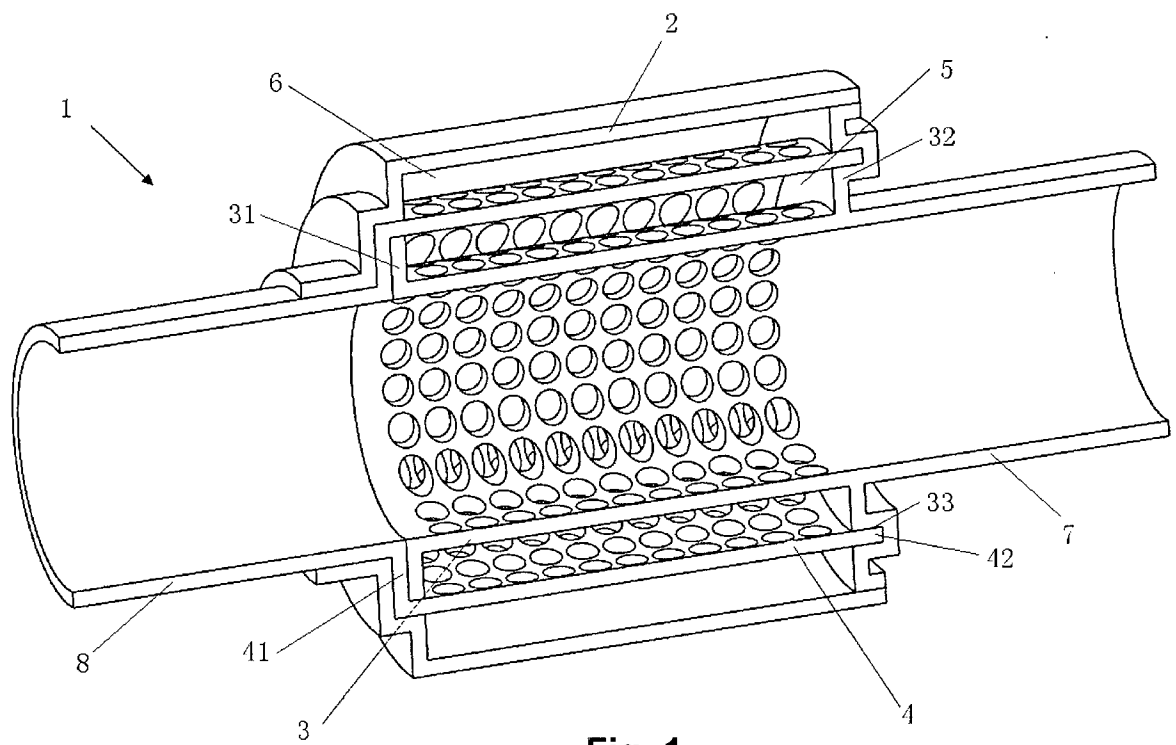
6. Silencer as claimed in claim 1, characterized in that the second chamber (6) is configured so as to only be in a partial circumferential region of the central perforated tube (3).

7. Silencer as claimed in claim 6, characterized in that the second chamber (6) is configured as a box-shaped structure which has a radially outward opening, and the outer housing (2) has a cover plate adapted to close the opening.

8. Silencer as claimed in any one of the previous claims, characterized in that the first chamber (5) and/or the second chamber (6) is separated axially into a plurality of sub-chambers (51, 52, 53, 61, 62, 63) communicated with each other by a perforated member (19).

9. Silencer as claimed in any one of the previous claims, characterized in that the silencer (1) is adapted for use in an air inlet system of a vehicle engine and/or the at least one second chamber (6) comprises a plurality of second chambers (61, 62, 63) which are located radially with respect to each other, and the adjacent second chambers (61, 62, 63) are communicated with each other by perforates.

10. Air inlet system of a vehicle engine, characterized in that the air inlet system has a silencer (1) as claimed in any one of claims 1-9.



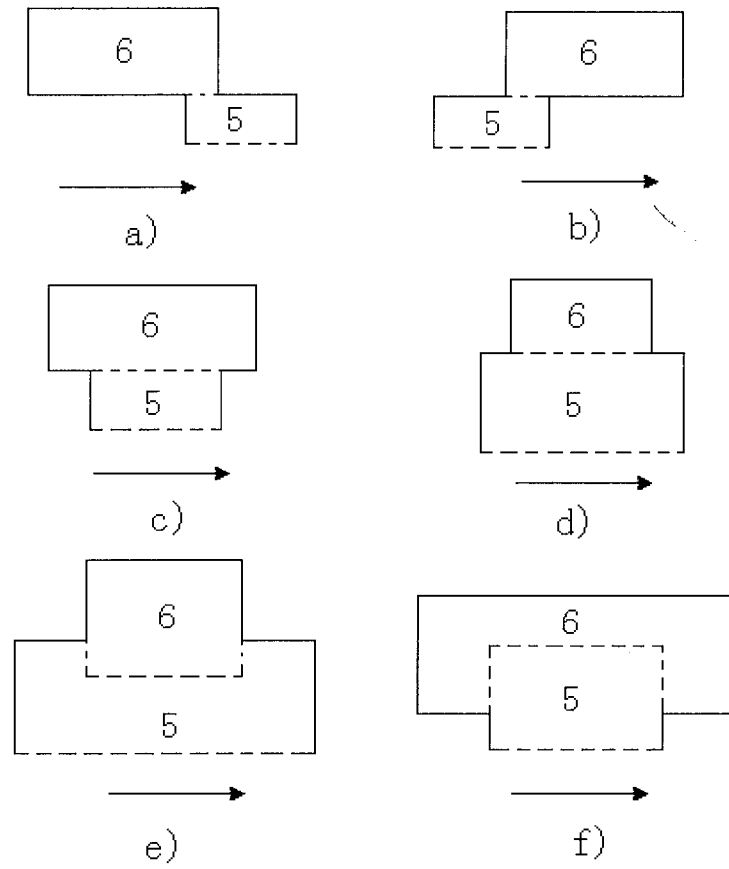


Fig. 2

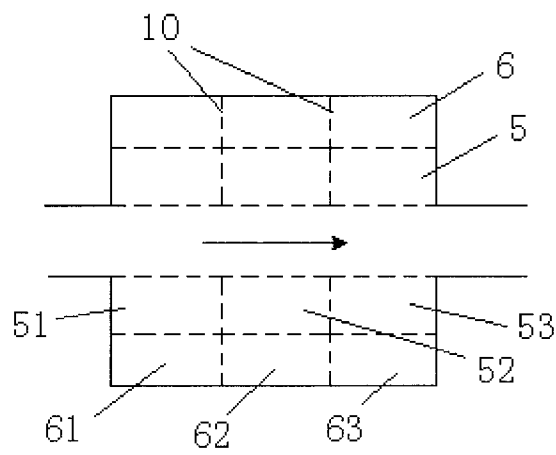


Fig. 3

INTERNATIONAL SEARCH REPORT

International application No

PCT/EP2016/065117

A. CLASSIFICATION OF SUBJECT MATTER
 INV. F02M35/12 F01N1/02
 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)
 F02M 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 2011/100083 A2 (FAURECIA EMISSIONS CONTROL TECHNOLOGIES USA LLC [US]; KEESSER THORSTEN) 18 August 2011 (2011-08-18) paragraph [0029] - paragraph [0033]; figures 1, 2, 6 -----	1-10
X	US 4 589 517 A (FUKUDA MASUO [JP]) 20 May 1986 (1986-05-20) column 2, line 15 - column 4, line 8; figures 1, 3, 6 -----	1-7,9,10
X	GB 450 398 A (ALAN ARNOLD GRIFFITH) 16 July 1936 (1936-07-16) page 2, line 26 - line 36 page 3, line 60 - line 94; figures 2, 3 ----- -/-	1-6,9,10



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

8 September 2016

Date of mailing of the international search report

20/09/2016

Name and mailing address of the ISA/

European Patent Office, P.B. 5818 Patentlaan 2
 NL - 2280 HV Rijswijk
 Tel. (+31-70) 340-2040,
 Fax: (+31-70) 340-3016

Authorized officer

Rauch, Vincent

INTERNATIONAL SEARCH REPORT

International application No

PCT/EP2016/065117

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2 904 125 A (BOURNE ROLAND B ET AL) 15 September 1959 (1959-09-15) figures 1, 2, 6 -----	1-6,9,10
X	EP 1 507 071 A1 (ZEUNA STAERKER KG [DE]) 16 February 2005 (2005-02-16) page 0022 - paragraph 0028; claims 12, 13, 18; figures 1, 3 -----	1-6,8-10
A	GB 610 000 A (ARNOLD FREEDMAN) 8 October 1948 (1948-10-08) page 1, line 6 - line 11 page 2, line 111 - line 121 -----	6,9,10

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/EP2016/065117

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 2011100083	A2	18-08-2011	CN 102753792 A 24-10-2012
			EP 2534343 A2 19-12-2012
			US 2012292128 A1 22-11-2012
			WO 2011100083 A2 18-08-2011

US 4589517	A	20-05-1986	NONE

GB 450398	A	16-07-1936	NONE

US 2904125	A	15-09-1959	NONE

EP 1507071	A1	16-02-2005	EP 1507071 A1 16-02-2005
			EP 2851526 A1 25-03-2015

GB 610000	A	08-10-1948	NONE
