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(54) Title: A BROADBAND SILENCER

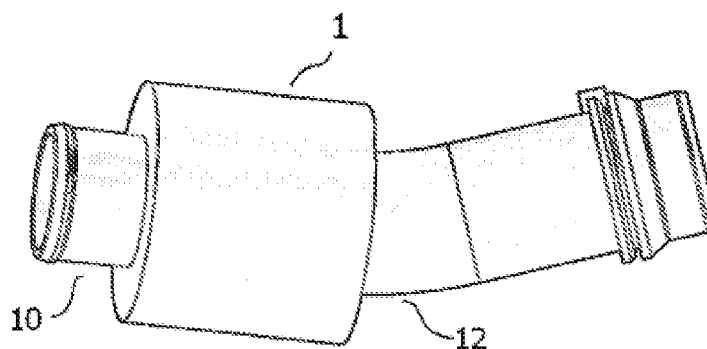


Figure 1

(57) Abstract: The present invention relates to a broadband silencer that is used for attenuating the noise generated due to the air flow. The present invention especially relates to a resonator that is used for the aim of attenuating the noise in air intake conduits of the internal combustion engines used in vehicles, that can perform attenuation in a wide, both low and high, frequency range, and whereof the effective frequency range can be easily optimized with respect to different flow conduits.

A Broadband Silencer

Related Technical Field

The present invention relates to a broadband silencer that is used for attenuating the noise generated due to the air flow.

The present invention especially relates to a resonator that is used for the aim of attenuating the noise in air intake conduits of the internal combustion engines used in vehicles, that can perform attenuation in a wide, both low and high, frequency range, and whereof the effective frequency range can be easily optimized with respect to different flow conduits.

Prior Art

In internal combustion engines, silencers are widely used on intake conduits in order to minimize the noise generated while the air received from outside by suction is delivered to the engine.

The frequency of the noise that is generated during air intake has a wide band range including both low and high. Therefore, the silencers are required to attenuate sound in a considerably wide range. In internal combustion engines, perforated pipe resonators with relatively low pressure losses are used in order to fulfill this attenuation requirement.

The resonator, one example of which is explained in the Patent No. US5839405, comprises a perforated inner pipe, a casing fitted over the pipe and resonator chambers formed by the walls in the area remaining therebetween. Each chamber communicates with the flow circuit by means of the holes formed on the inner pipe.

However, it is not possible to perform attenuation that encompasses the entire frequency range with a single resonator. Therefore, attenuation is performed at the frequency range where noise is at the peak intensity. However, when different motor types and different intake conduits are taken into consideration, the range where noise is at the peak intensity

shows variability. Optimizing the resonator for different frequency ranges with small design modifications provides advantage in terms of production and costs. By changing criteria like the number of perforations, the amount of perforations, the length of the inner pipe and volume of the chamber, the perforated pipe resonators that can attenuate in a wide band provide design flexibility and can be adjusted for the range where noise is at the peak intensity.

The resonator described in the Patent No. **EP0834011**, has a perforated inner pipe and a casing, wherein the resonator chambers that are formed by partitions, have different volumes. The resonator realizes an attenuation capability from 1 to 10 kHz by changing the volume and axial arrangement of the chambers.

In the Patent No. **US6983820**, use of spacers are disclosed, which can be inserted to close some of the perforations on the inner pipe to provide flexibility in the frequency band range attenuated.

However, in frequency bands less than 1 kHz, it is known that these resonators with perforated inner pipe cannot provide sufficient performance in terms of transmission loss. Attenuation at low frequencies is performed by Helmholtz resonators comprising a narrow cylindrical neck and a large volume cavity which is connected to the flow conduit by means of this neck. It is known in the technique that attenuation can be performed at both low and high frequencies by using the Helmholtz resonators together with different types of resonators. However, silencers of this type occupy a great volume due to the structure of Helmholtz resonators.

In the Patent No. **US3920095**, a design providing attenuation at both high and low frequencies by comprising Helmholtz and quarter wave resonators connected in series, is described. In the attenuator, there is an inner pipe, a casing fitted over the pipe, and a first cavity remaining between the two. A second cavity is formed between an inner wall inside the said cavity and the inner pipe. The first cavity communicates with the inner pipe by ports and forms the Helmholtz resonator for low frequency sounds. On the other hand, the inner pipe has a porous structure at the region of the second cavity and the communication

between the inner pipe and the second cavity is provided by means of these pores. The second cavity that is divided into more than one chamber by plates attenuates high frequency sounds.

The design disclosed in the above mentioned patent aims to increase the high frequency attenuation by eliminating the low frequency noise in the flow. Therefore, unless the low frequency attenuation is realized at a sufficient level, the porous inner pipe does not allow the flow to pass into the second cavity and high frequency attenuation is not performed. Therefore, the two resonators are not directly connected and the connection is realized through the flow conduit. This design requires a great volume since the Helmholtz resonator is formed by the first cavity. More importantly, it causes high pressure losses because of the large volume cavity. The volume occupied by the resonator increases further especially when more than one Helmholtz resonator is required.

In order to eliminate the disadvantages mentioned above, the present invention discloses a broadband silencer which can attenuate both low and high frequency sounds, that can be easily optimized to the desired frequency range, which is compact and occupies less space, comprising a perforated inner pipe, an outer pipe that is fitted thereover coaxially, at least one resonance chamber formed therebetween for attenuating high frequencies and at least one tube formed inside this chamber/chambers for attenuating low frequencies.

The present invention is described below in detail with reference to the figures.

Figure 1 shows a portion of the air intake conduit that comprises the silencer.

Figure 2 is the cross-sectional view of the silencer of the present invention.

Figure 3a is the cross-sectional view of the silencer of the present invention having two tubes.

Figure 3a is the cross-sectional view of the silencer of the present invention having four tubes.

Figure 4 is the exploded isometric view of the silencer of the present invention.

Figure 5a is the cross-sectional view of the silencer wherein the tube is connected by means of the lugs.

Figure 5b is the detailed view of the section where the lugs are located in Figure 5a.

Figure 6a is the cross-sectional view of the tube.

Figure 6b is the detailed view of the section of the tube where the lug is located.

Figure 7a is the cross-sectional view of the silencer before the tube is mounted.

Figure 7b is the detailed view of the boundary walls that contain the housings.

The elements related to the present invention are numbered as follows in the above-described figures:

Silencer	1
Inlet end	10
Outlet end	12
Boundary walls	11,11'
Inner pipe	100
Partition walls	101
Opening	102
Outer pipe	120
Resonance chambers	131,132,133
Tube	140
Open end of the tube	141
Closed end of the tube	142
Housing	143
Flat wall	144
Lug	145
Hole	150
One-piece element	160

Detailed Description of the Invention

The silencer (1) of the present invention is a cylindrical structure connected to the air intake conduits from two ends (10, 12) as shown in Figure 1.

The silencer (1) of the present invention shown in cross-sectional view in Figure 2, comprises a perforated inner pipe (100) , an outer pipe (120) fitted coaxially thereover, at least one resonance chamber (131 - 133) formed therebetween for attenuating high frequency noise and at least one tube (140) provided in this chamber/chambers (131 - 133) for attenuating the low frequency noise. Both ends of the outer pipe (120) are closed by the boundary walls (11, 11'). The sucked air enters from the inlet end (10) of the silencer (1) into the perforated inner pipe (100) and is supplied to the flow conduit from the outlet end (12). Meanwhile, some portion of the flow passes through the holes (150) on the inner pipe (100) and fills into the resonance chambers (131 - 133) between the two pipes (100, 120) and the tubes (140) contained in these chambers (131 - 133). Thus, while the resonance chambers (131 - 133) attenuate high frequency sound waves, the tubes (140) attenuate low frequency sound waves.

The silencer (1) of the present invention can comprise a multiple number of resonance chambers (131, 133), provided that there is at least one. As shown in Figure 2, the silencer (1) preferably comprises three resonance chambers (131, 132, 133) that are formed by means of two radial partition walls (101). The silencer (1) has at least one tube (140) that is provided in the silencer chambers (131 - 133) which extends preferably vertical to these partition walls (101) and parallel to the inner and outer pipes (100, 120). One end (142) of the tube (140) is adjacent to the boundary wall (11') of the silencer (1) and the other end (141) thereof is positioned in a position open to one of the resonance chambers (131-133).

The open end (141) of the tube (140) is preferably located towards the inlet (10) side.

The cross-section of the tube (140) is preferably circular, but it can also be in different shapes like elliptic or quadrangular. The tube (140) preferably has a constant cross-section along the longitudinal axis. However, in different embodiments, it may narrow or widen either gradually from one end to the other (141, 142) or regionally at certain portions. The tube (140) can also be positioned so as to make an angle between 5 to 175 degrees with the radial partition walls (101).

The silencer (1) of the present invention is effective over a considerably wide range of frequencies by means of the tubes (140) and the resonance chambers (131-133). Additionally, the design provides the flexibility for easily changing the frequency range where the attenuation is performed. The performance of the tube (140) contained in the chamber (131-133) can change with respect to the frequency range in the chamber (131-133) where the tube (140) opens.

The tube (140) provided in the silencer (1) of the present invention can open to anyone one of the chambers (131-133) arranged with respect to the flow direction. Thus, the attenuation frequency range of the silencers (1) can be modified without changing the features like the volume of the resonance chambers (131-133), the number and diameter of the holes (150) on the inner pipe (100) that open to these chambers (131-133). Optimization of the silencer (1) to the desired range at low frequencies can be realized by changing the chamber (131-133) into which the tube (140) opens.

The resonance chambers (131-133) disclosed in the present invention preferably have equal volumes, however depending on the application they can vary as well. The resonance chambers with different volumes will be effective at different frequency ranges. Thus, the high frequency attenuation band of the silencer (1) can be changed in this way. Additionally, the low frequency attenuation band of the silencer (1) can be altered by changing the volume of the chamber (131-133) into which the tube (140) opens. Thus, by changing the chamber (131-133) volumes in the silencer (1) of the present invention, the attenuation band can be adjusted at both high and low frequencies.

The silencer (1) of the present invention, whereof a different version is shown in Figure 3a, has two tubes (140) that are positioned angularly. In the silencer (1) shown in the figure, the tubes (140) open to different chambers (131, 132), however depending on the particular application, they can also open into the same chamber. The number of tubes (140) that the silencer (1) comprises can be increased as in Figure 3b. The tubes (140) can be arranged radially, angularly or axially in the silencer (1). Furthermore, the attenuation frequency range of the silencer (1) can be easily changed by adjusting the dimensions of these tubes (140) to be the same or different from each other if desired.

Although effective in a narrow band, the tube or the tubes (140), provide the possibility of optimization of low frequency attenuation performance by adjusting the variables like the number of them provided in the silencer, their length, volume, cross-section, position of the open end (141) with respect to the flow direction, the chamber to which (131-133) they open and the volume of said chamber. Furthermore, in the silencer (1) of the present invention, the portion attenuated in high frequency range can be adjusted by changing the number of resonance chambers (131-133), the volumes of these chambers (131-133) and the number of holes (150) opening into these volumes. Similarly, the cross-section of the perforations, which is preferably provided as circular holes (150) on the inner pipe (100), can be changed. Perforation can be provided by holes of circular or elliptical cross-sections and/or slits with quadrangular/oval cross-sections. Moreover, the number of perforations, the diameters, cross-sections of perforations, the position and arrangement of these perforations can be changed.

In the silencer (1) shown in a pre-assembly state in Figure 4, the inner pipe (100), the partition walls (101) and one of the boundary walls (11') are produced as a single piece. This one-piece element (160) is inserted into the outer pipe (120). The other boundary wall (11) is shown as integrated with the outer pipe (120) in the figure but can also be formed on the inner pipe (100). Openings (102) through which the tube (140) can pass, are provided on the boundary wall (11') and on the partition walls (101). The assembly of the silencer (1) is completed by inserting the tube (140) through these openings (102).

The tube (140) can be mounted into the silencer (1) by any one of the leak-proof connection methods known in the technique.

In an embodiment, the tube (140) is connected to the silencer (1) by fitting the flexible lugs (145) formed thereon over the boundary wall (11'). In this embodiment depicted in Figure 5, the tube (140) is placed into the openings (102) provided on the partition walls (101) and the boundary wall (11') and is fixed to the silencer (1) by said lugs (145) being inserted into two housings (143) provided on the boundary wall (11') as shown in detail in Figure 7.

Alternatively, the lugs (145) can be formed on the boundary wall (11') of the silencer (1) and the housings (143) on the flat wall (144) that closes the end (142) of the tube (140).

In Figure 6, the tube (140) having flexible lugs (145) thereon is shown and in Figure 7, the boundary wall (11') which matches thereto is shown in more detail. Preferably, two lugs (145) are included in the closed end (142) of the tube (140) that is mounted to the silencer (1). The lugs (145) are placed on a flat wall (144) that closes the end (142) of the tube (140) and that has a greater diameter than the tube (140). However, in different embodiments, the lugs (145) can also be positioned to be adjacent to the tube (140) without the flat wall (144). Moreover, the number of lugs (145) can be decreased or increased. . The housing (143) is a hole with quadrangular cross-section, however it can be formed in different shapes depending on the cross-section of the lug (145). The housing (143) can also be obtained with a hollow element that extends outwards from the boundary wall (11') instead of a hole. The housings (143) that are aligned with the lugs (145) can be positioned at any section of the boundary wall (11') with respect to the position of the lugs (145). They (143) are preferably separate to the opening (102) whereto the tube (140) is inserted. However, in different embodiments housings (143) and the opening (102) can have a common boundary. The number of housings (143) can be increased or decreased depending on the lugs (145).

Alternatively, the tube (140) can also be produced to be integrated with the boundary wall (11'). In this embodiment, there are again openings (102) on the partition walls (101) and the tube (140) after being inserted into these openings (102) is placed leak-proofingly into the silencer (1) by means of joining the boundary wall (11') with the outer pipe (120) and the inner pipe (100).

In a different embodiment, the tube (140) can be joined to the boundary wall (11') by welding or adhesion. For welding, ultrasonic, rotation, vibration, butt or a different welding method known in the technique can be selected.

Claims

1. A silencer (1) that is used in air intake conduits, especially in engine air circuits of the internal combustion engines, **characterized by** comprising a perforated (150) inner pipe (100), an outer pipe (120) mounted over said inner pipe (100) and of which the two ends (10,12) are closed by boundary walls (11, 11'), at least one resonance chamber (131-133) formed between the inner and the outer pipes (100, 120) for attenuating the high frequency noise and at least one tube (140) provided in the said chamber/chambers (131-133) for attenuating low frequency noise.
2. A silencer (1) as in Claim 1, **characterized in that** one end (142) of the said tube (140) is adjacent to the said boundary wall (11') and the other end (141) thereof is open.
3. A silencer (1) as in Claim 2, **characterized in that** the said open end (141) is located towards the inlet (10) side.
4. A silencer (1) as in Claim 1, **characterized in that** the cross-section of the said tube (140) is circular, elliptical or quadrangular.
5. A silencer (1) as in Claim 4, **characterized in that** the cross-section of the said tube (140) is constant along the longitudinal axis.
6. A silencer (1) as in Claim 4, **characterized in that** the cross-section of said tube (140) narrows or widens either gradually from one end (141, 142) to the other (141, 142) along the longitudinal axis or at a certain section of the tube (140).
7. A silencer (1) as in any one of the above claims, **characterized in that** more than one resonance chamber (131, 132, 133) is provided between the said inner and outer pipes (100, 120), separated from each other by means of partition walls (101).
8. A silencer (1) as in any one of the above claims, **characterized in that** said open end (141) of the tube (140) is positioned in any one of the said resonance chambers (131-133).

9. A silencer (1) as in any one of the above claims, **characterized in that** said tube (140) extends parallel to the inner pipe (100) or the outer pipe (120).
10. A silencer (1) as in any one of the above claims, **characterized in that** said tube (140) is positioned so as to make an angle between 5 and 175 degrees with the said partition walls (101).
11. A silencer (1) as in the previous claim, **characterized in that** the said tube (140) is positioned so as to be vertical to the said partition walls (101).
12. A silencer (1) as in any one of the above claims, **characterized in that** the said tube (140) is provided so as to pass through at least one opening (102) formed on the said partition walls (101).
13. A silencer (1) as in Claim 12, **characterized in that** the said tube (140) is fixed to the said boundary wall (11') by passing through an opening (102) provided on the said boundary wall (11').
14. A silencer (1) as in Claim 13, **characterized in that** the said tube (140) is fixed to the said boundary wall (11') by means of at least one flexible lug (145) and at least one housing (143) where to the lug (145) is fitted.
15. A silencer (1) as in Claim 13, **characterized in that** the said tube (140) is fixed to the said boundary wall (11') by means of adhesion or welding.
16. A silencer (1) as in Claim 14, **characterized in that** the said housing (143) is provided on the boundary wall (11') and the lug (145) on the tube (140).
17. A silencer (1) as in the previous claim, **characterized in that** the said lug (145) is provided on the flat wall (144) that closes one end (142) of the tube (140).
18. A silencer (1) as in Claim 14, **characterized in that** the said lug (145) is provided on the boundary wall (11') and the housing (143) on the tube (140).

19. A silencer (1) as in Claim 12, **characterized in that** the said tube (140) is provided to be integrated with the said boundary wall (11').
20. A silencer (1) as in any one of the above claims, **characterized in that** more than one tube (140) is provided.
21. A silencer (1) as in Claim 20, **characterized in that** the said tubes (140) have different dimensions from each other.
22. A silencer (1) as in Claim 20, **characterized in that** the said tubes (140) are provided so as to open into the same chamber (131-133).
23. A silencer (1) as in Claim 20, **characterized in that** the said tubes (140) are provided so as to open into different chambers (131-133).
24. A silencer (1) as in any one of the above claims, **characterized in that** the said resonance chambers (131-133) have equal volumes.
25. A silencer (1) as in any one of the above claims, **characterized in that** the said resonance chambers (131-133) have different volumes.

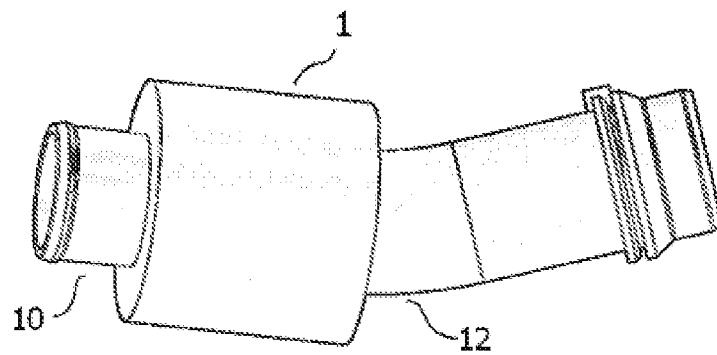


Figure 1

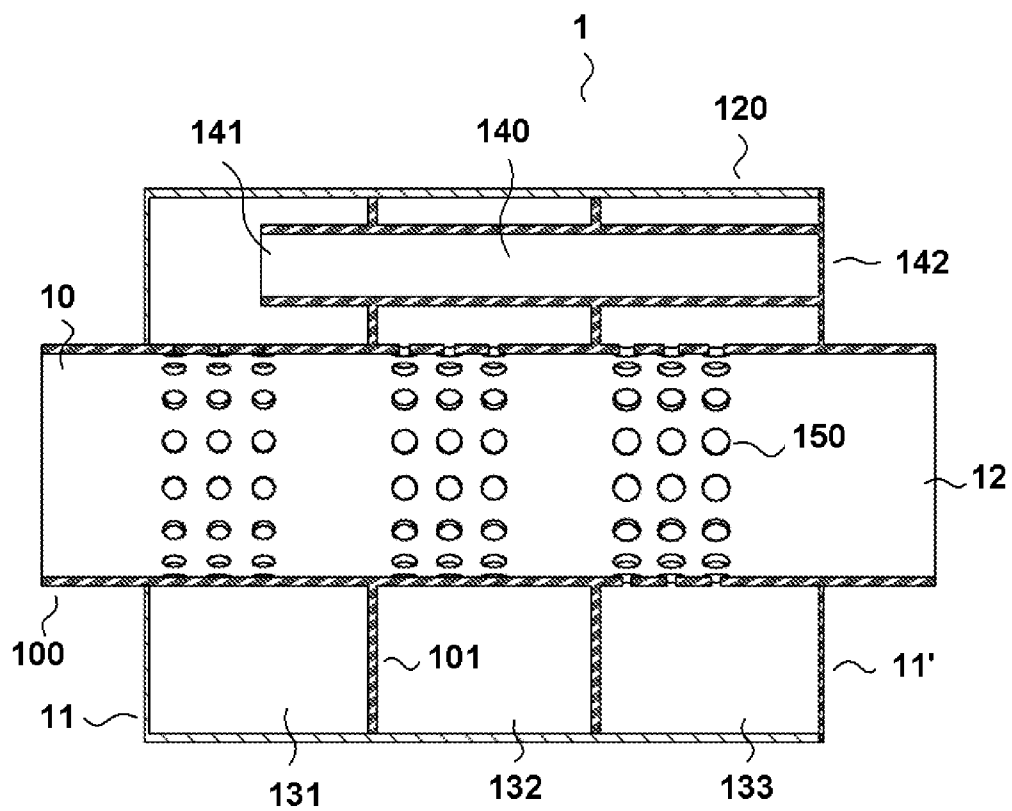


Figure 2

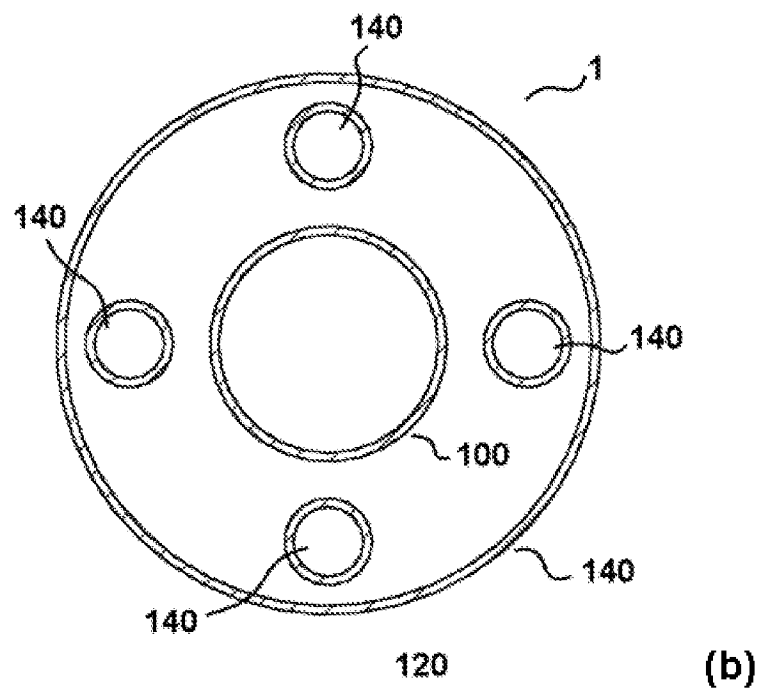
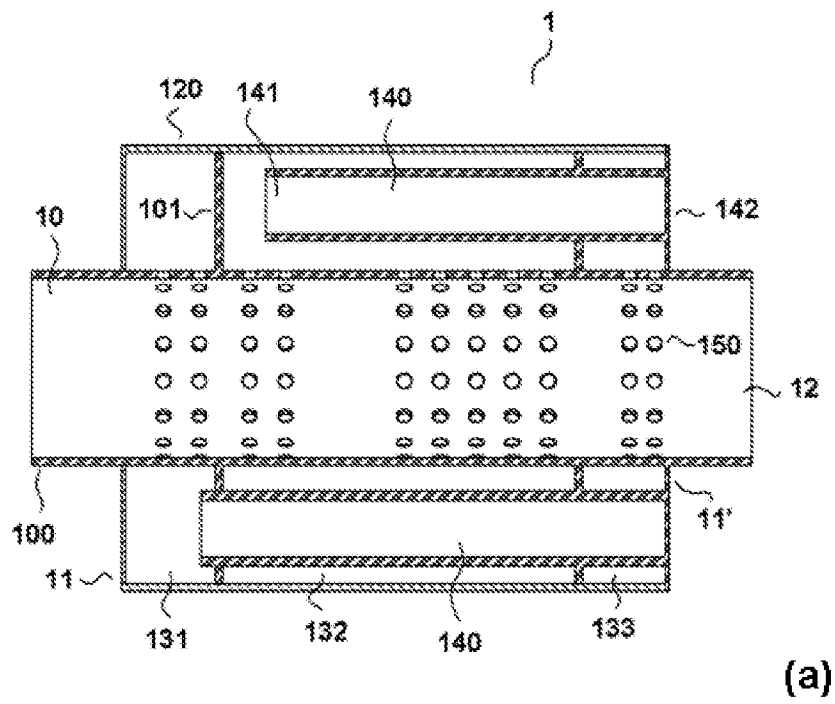


Figure 3

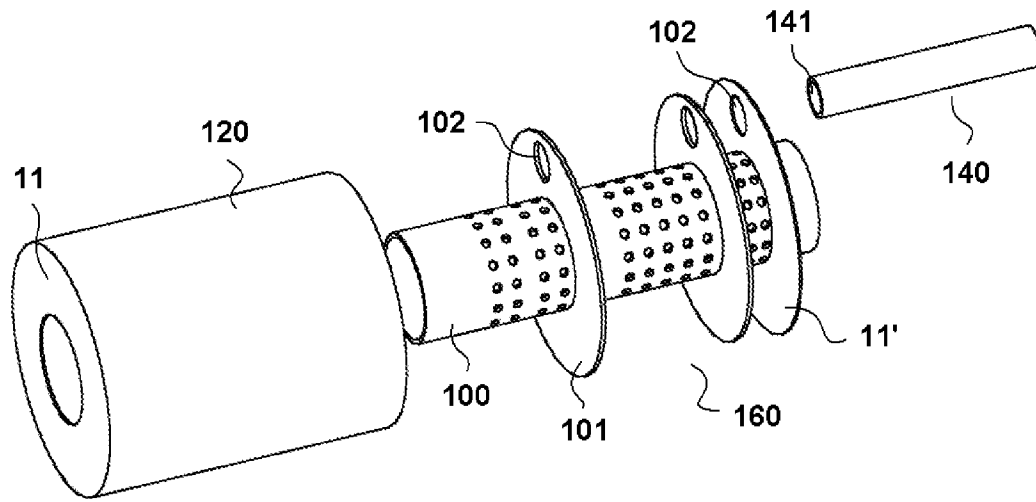


Figure 4

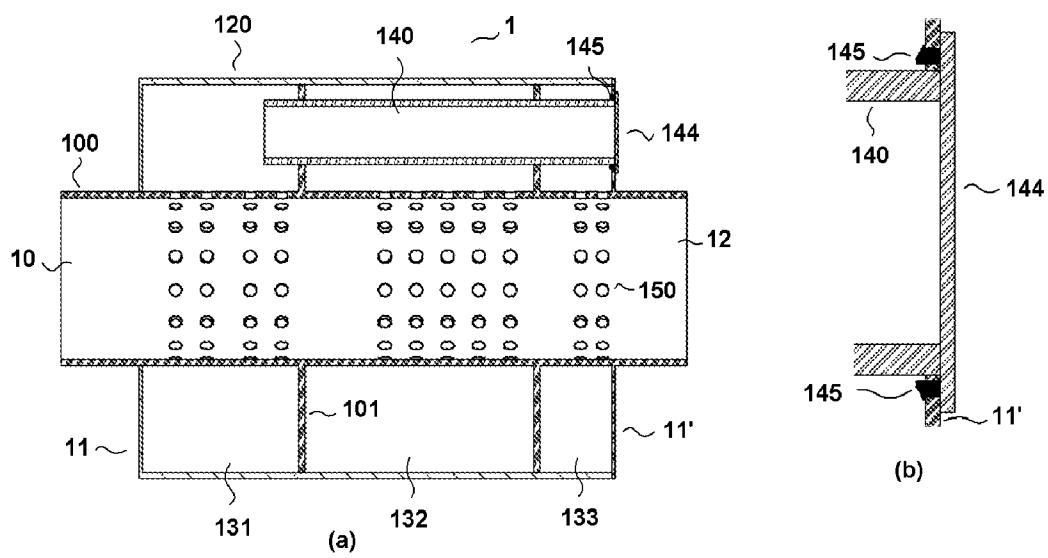


Figure 5

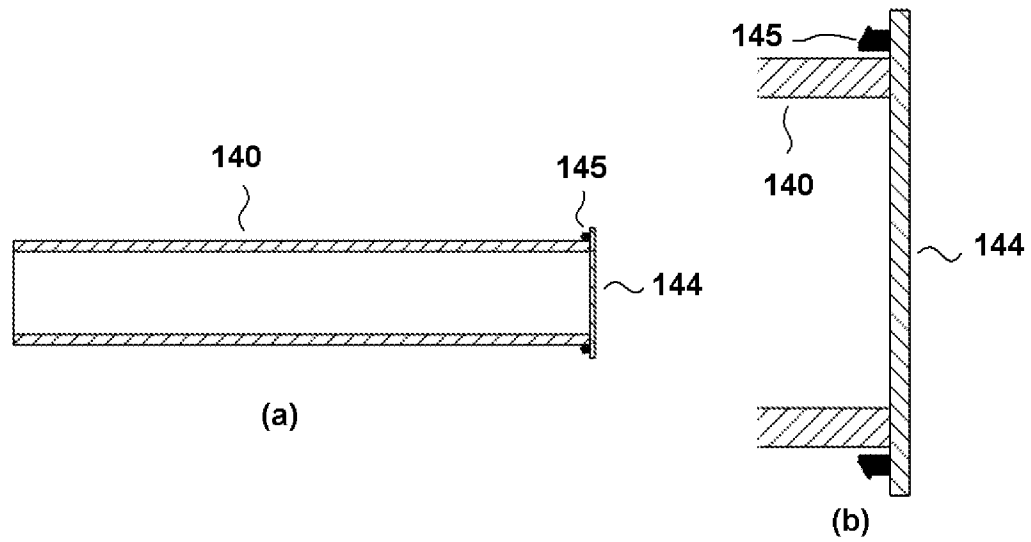


Figure 6

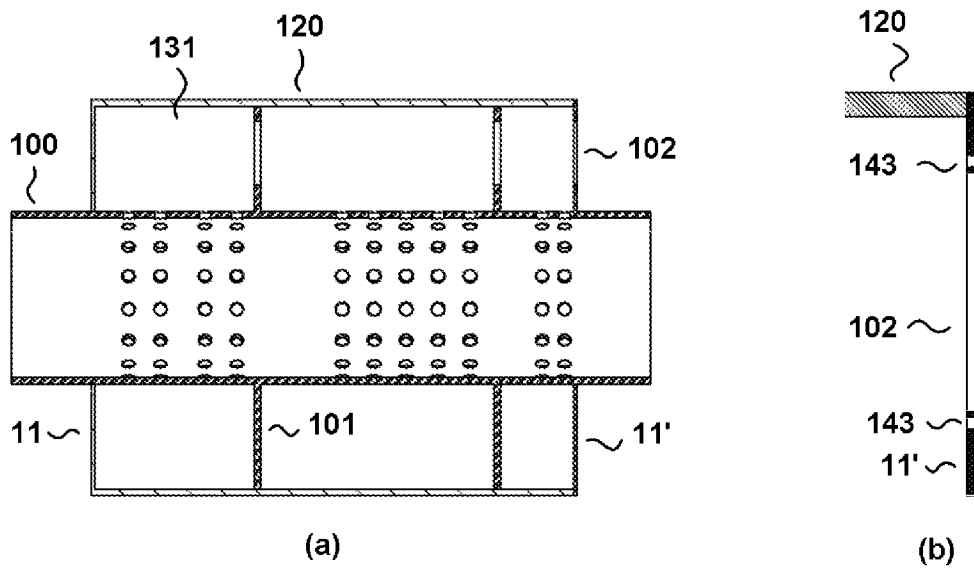


Figure 7

INTERNATIONAL SEARCH REPORT

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A. CLASSIFICATION OF SUBJECT MATTER
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According to International Patent Classification (IPC) or to both national classification and IPC

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 F02M

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

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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X A	US 2 271 055 A (WILSON ERNEST E) 27 January 1942 (1942-01-27) figures 3,4 page 2, column 1, paragraph 49-56 page 2, column 2, lines 16-23 -----	1,4-12, 20-25 2,13,19
X	US 2 196 491 A (CHIPLEY ALFRED S) 9 April 1940 (1940-04-09) figures 3,4 page 1, column 1, paragraph 1-10 page 4, column 1, paragraph 33-39 -----	1-6, 9-11, 13-25
X A	US 4 874 062 A (YANAGIDA KOUICHI [JP] ET AL) 17 October 1989 (1989-10-17) figures 1-6,11,12 column 1, lines 11-14 ----- -/-	1,4-12, 20-25 2,13,19



Further documents are listed in the continuation of Box C.



See patent family annex.

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Date of the actual completion of the international search

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Date of mailing of the international search report

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Name and mailing address of the ISA/

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Aubry, Yann

INTERNATIONAL SEARCH REPORT

International application No

PCT/IB2013/061373

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

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