



(11) **EP 1 253 312 A1**

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
30.10.2002 Bulletin 2002/44

(51) Int Cl.7: **F02M 35/14**, F02M 35/12,
F02M 35/00, F02B 27/02

(21) Application number: **02008733.4**

(22) Date of filing: **18.04.2002**

(84) Designated Contracting States:
AT BE CH CY DE DK ES FI FR GB GR IE IT LI LU
MC NL PT SE TR
Designated Extension States:
AL LT LV MK RO SI

(72) Inventors:
• **Cornaglia, Umberto**
10027 Testona (IT)
• **Tarabocchia, Alessio**
10100 Torino (IT)

(30) Priority: **26.04.2001 IT MI20010873**

(74) Representative: **Franzolin, Luigi et al**
STUDIO TORTA S.r.l.,
Via Viotti, 9
10121 Torino (IT)

(71) Applicant: **OFFICINE METALLURGICHE G.**
CORNAGLIA S.p.A.
10092 Beinasco (IT)

(54) **Low-noise integrated air-filtering device**

(57) Low-noise integrated air-filtering device, including a casing (2), which has an inlet pipe (3) and an outlet pipe (4), and a filter element (5), which is set inside said casing (2). The integrated device is further provided

with a silencer device (7) including at least one resonator element (8) and one first damping element (10), which are set in series together and are contained inside said casing (2). Said resonator element (8) has a neck (12) having a length (L) that can be adjusted.

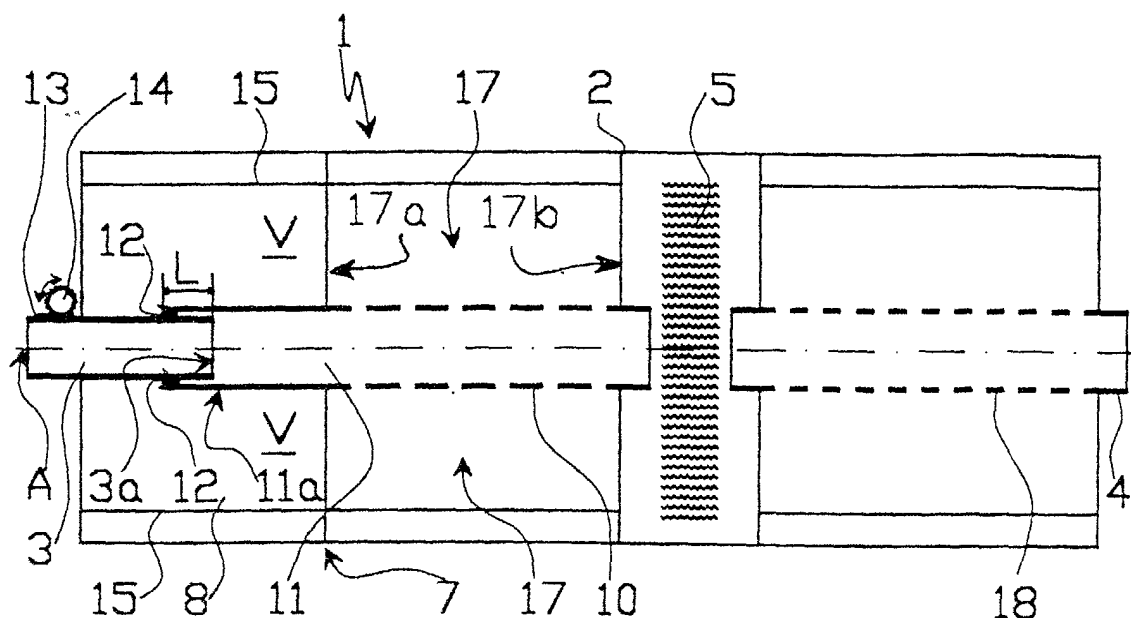


Fig. 1

Description

[0001] The present invention relates to a low-noise integrated air-filtering device.

[0002] As is known, noise reduction in reciprocating-type engines, especially internal-combustion engines for vehicles for non-military use, is a requirement that is assuming an ever-increasing importance. The said noise is mainly caused by pressure waves that are generated on account of the reciprocating motion of the pistons in the cylinders and that propagate along the air-intake and exhaust-gas pipes.

[0003] Consequently, in order to achieve the aim, silencer devices, such as perforated-plug elements, are currently employed, which enable conversion of part of the energy associated to the pressure waves into heat. Normally, the silencer devices are set along the exhaust pipe and contribute to reducing considerably the overall noise level of the engine.

[0004] Frequently, however, this is not sufficient, and it is necessary to adopt additional solutions. In particular, it is possible to add further silencer elements also along the air-intake pipe, for example upstream of the air-intake filter.

[0005] The known solutions, however, present a number of drawbacks, which are linked mainly to the encumbrance, in so far as the silencer elements currently available must be inserted externally to the air-intake filter, and which are linked to the characteristics of noise-deadening of the silencer device, which can be made by assembling distinct elements together.

[0006] As is known to a person skilled in the branch, in fact, the performance of a silencer device is markedly affected by the geometry both of the device itself and of the flow of air that conveys the noise that is to be attenuated. On the other hand, the use of distinct silencer elements that are assembled along the air-intake pipe does not enable an optimal geometry, and hence noise is reduced only partially.

[0007] Furthermore, it is not possible to modify either the dimensions or the noise-attenuation characteristics of the individual elements that form the silencer device, which consequently is not suitable for being used on engines that are different, for example, in terms of displacement or in terms of other constructional features. It is thus necessary to provide different elements according to the type of engine on which the said elements are to be used, and this entails high production costs.

[0008] The purpose of the present invention is to provide a low-noise integrated air-filtering device which enables the above-mentioned drawbacks to be overcome and which, moreover, is of simple and inexpensive implementation.

[0009] Provided in accordance with the present invention is a low-noise integrated air-filtering device, comprising a casing, which has an inlet pipe and an outlet pipe, and a filter element, which is set inside said casing, characterized in that it comprises a silencer device in-

cluding at least one resonator element and one first damping element, which are set in series together and are contained inside said casing.

[0010] In this way, the device is not only compact and of reduced overall dimensions, but can also be built with an optimal geometry which enables noise abatement in an extremely efficient way. In particular, the use of a resonator element and a damping element, which substantially operate in contiguous frequency bands, makes it possible to achieve a high damping effect over a wide spectrum of frequencies.

[0011] In addition, the device forms a single body which can be conveniently mounted on different engines as a replacement for the traditional air-intake filter.

[0012] According to a further aspect of the present invention, said resonator element, said first damping element, and said filter element form an axial sequence.

[0013] In addition, the device has a centroidal axis of symmetry, and said resonator element, said first damping element and said filter element define a linear pipe which is coaxial with said centroidal axis of symmetry.

[0014] The linear geometry and the symmetry of the pipe with respect to a centroidal axis of symmetry enable effective reduction of the undesired effects of resonance due to the transverse modes of propagation of the pressure waves, and thus enable a further improvement in noise deadening.

[0015] For a better understanding of the present invention, an embodiment thereof will be described hereinafter, purely by way of non-limiting example and with reference to the attached drawings, in which:

- Figure 1 is a simplified diagram of an integrated device according to the present invention, in a longitudinal cross-sectional view; and
- Figure 2 presents plots of quantities regarding the device of Figure 1.

[0016] With reference to Figure 1, a low-noise integrated air-filtering device, designated as a whole by 1, comprises a casing 2, which has a longitudinal axis A of symmetry, an inlet pipe 3 and an outlet pipe 4, which are coaxial to the longitudinal axis A. Housed inside the casing 2 are a filter cartridge 5, of a type in itself known, and a silencer device 7, which includes at least one resonator element 8 and one first damping element 10. In detail, the resonator element 8, the first damping element 10 and the filter cartridge 5 are set in series together and form an axial sequence, in which the resonator element 8 and the first damping element 10 are set upstream of the filter cartridge 5.

[0017] According to the present invention, the longitudinal axis A of symmetry is also a centroidal axis of the device 1. In addition, the resonator element 8, the first damping element 10 and the filtering cartridge 5 define a linear pipe 11 coaxial to the longitudinal axis A of symmetry. In particular, the linear pipe 11 is traversed by a flow of air sucked in towards the engine (not

shown). The said flow of air conveys pressure waves which are generated by the engine itself during its normal operation and which are the source of the noise that is to be attenuated.

[0018] Preferably, the resonator 8 is an in-line Helmholtz resonator and has a neck 12, which has an adjustable length L, and a volume V. In this way, the resonator element 8 is particularly suited for attenuating noise in a medium-to-low frequency band, up to approximately 300 Hz. In addition, the frequency of maximum damping can be adjusted, as will be explained hereinafter.

[0019] In detail, the neck 12 of the resonator element 8 has an annular shape and is defined comprised between an outlet stretch 3a of the inlet pipe 3 and a first stretch 11a of the linear pipe 11.

[0020] In particular, the outlet stretch 3a of the inlet pipe 3 is inserted, in an axially slidable way, inside the first stretch 11a of the linear pipe 11.

[0021] The axial position of the inlet pipe 3 with respect to the linear pipe 11 (and hence the length L of the neck 12) can be adjusted by means of an actuation device, comprising, for example, a rack 13, carried integrally by the inlet pipe 3 and set longitudinally, and a gear 14, driven by a motor, of a known type and not illustrated.

[0022] Optionally, a diaphragm 15 can be inserted inside the casing 2 in order to reduce by a pre-set amount the volume V of the resonator element 8.

[0023] The first damping element 10 is a perforated-plug element with low density of perforation, for attenuation of the noise in a medium-to-high frequency band, up to approximately 900 Hz. For example, the density of perforation is between approximately 4% and 5%.

[0024] An annular region, which is defined between the casing 2 and the first damping element 10 and which moreover is axially delimited by a first wall 17a and a second wall 17b, forms an expansion chamber 17, which contributes to attenuating the noise generated by the engine, as will be explained later on with reference to Figure 2.

[0025] According to a preferred embodiment of the present invention, the integrated device 1 comprises a second damping element 18, set inside the casing 2, downstream of the filter cartridge 5. In addition, the second damping element 18 is coaxial to the longitudinal axis A of symmetry and is connected to the outlet pipe 4. In particular, the second damping element 8 is a perforated-plug element with high perforation density for noise damping in a high-frequency band, substantially with frequencies higher than 600 Hz.

[0026] Figure 2 shows damping curves of the resonator element 8, of the first damping element 10 and of the expansion chamber 17 in a frequency band of between 0 and 1000 Hz. In detail, the damping curve for the resonator element 8 is illustrated with a solid line; the damping curve for the first damping element 10 is illustrated with a dashed line; and the damping curve for the expansion chamber 17 (i.e., due exclusively to a sharp var-

iation in the section of the pipe in which the air flows) is illustrated with a dashed-and-dotted line.

[0027] As mentioned previously, when the engine on which the integrated device 1 is operating, the inlet pipe 3, the linear pipe 11 and the outlet pipe 4 of the integrated device 1 itself are traversed by a flow of air in which substantially periodic pressure waves, which are a source of noise, propagate.

[0028] The noise is mainly attenuated by the resonator element 8 and by the first damping element 10. The integrated device 1, as a whole, is particularly effective in damping transverse modes of propagation of the pressure waves. As is known to a person skilled in the branch, the said result can be obtained when the flow of air develops substantially about a centroidal axis of the damping device (in the case of the integrated device 1, the flow of air develops substantially about the longitudinal axis A of symmetry, which is a centroidal axis). In this way, in fact, it is possible to shift secondary resonance frequencies present in the damping and air-filtering devices towards high frequency values, namely ones that are outside the spectrum of frequencies of the pressure waves that generate noise. The said secondary resonance frequencies are not therefore excited, and undesired resonance effects are thus prevented.

[0029] In addition, the maximum attenuating frequency of the resonator element 8 can be adjusted. In an in-line Helmholtz resonator, such as the resonator element 8, the said maximum frequency of attenuation corresponds, in fact, to the characteristic resonance frequency F_R given by the following equation:

$$F_R = \frac{1}{2\pi} \sqrt{\frac{C^2 S}{L_{EFF} V}} \quad (1)$$

where C is the speed of sound, S is the area of a radial section of the neck 12 of the resonator element 8, and L_{EFF} is the effective length of the neck 12. The said effective length L_{EFF} is in turn defined, to a first approximation, by the following expression:

$$L_{EFF} = L + 0.8 \sqrt{S} \quad (2)$$

[0030] Clearly, the possibility of varying the axial position of the inlet pipe 3 with respect to the linear pipe 11 enables adjustment of the length L of the neck 12 of the resonator element 8 and, consequently, also its characteristic frequency of resonance F_R .

[0031] It is moreover evident from equation (1) that the characteristic frequency of resonance F_R can be modified also by varying the volume V of the resonator element 8. For this purpose, as mentioned previously, it is possible to insert, inside the casing 12, the diaphragm 15, which reduces the volume V by a pre-set amount. In this way, the integrated device 1 can be readily adapted to the noise characteristics of various engines.

[0032] Finally, it is clear that modifications and variations may be made to the integrated device described herein, without thereby departing from the scope of the present invention.

[0033] In particular, the sequence of the elements inside the casing 2 may be different from the one illustrated. For example, the resonator element 8 and the first damping element 10 may be set downstream of the filter cartridge 5; on the other hand, the second damping element 18 may be set upstream of said filter cartridge 5.

Claims

1. A low-noise integrated air-filtering device, comprising a casing (2), which has an inlet pipe (3) and an outlet pipe (4), and a filter element (5), which is set inside said casing (2), **characterized in that** it comprises a silencer device (7) including at least one resonator element (8) and one first damping element (10), which are set in series together and are contained inside said casing (2).
2. The device according to Claim 1, **characterized in that** said resonator element (8), said first damping element (10) and said filter element (5) form an axial sequence.
3. The device according to Claim 2, **characterized in that** it has a centroidal axis of symmetry (A), and **in that** said resonator element (8), said first damping element (10) and said filter element (5) define a linear pipe (11) coaxial to said centroidal axis of symmetry (A).
4. The device according to Claim 2 or Claim 3, **characterized in that** said resonator element (8) is an in-line Helmholtz resonator, and said first damping element (10) is a perforated-plug element with low perforation density.
5. The device according to Claim 4, **characterized in that** said resonator element (8) has a neck (12) having a length (L) that can be adjusted.
6. The device according to Claim 5, **characterized in that** said neck (12) of said resonator element (8) has an annular shape and is defined between an outlet stretch (3a) of said inlet pipe (3), which is inserted inside a first stretch (11a) of said linear pipe (11), and said first stretch (11a) of said linear pipe (11), said inlet pipe (3) being moreover axially slidable with respect to said linear pipe (11).
7. The device according to Claim 6, **characterized in that** it comprises an expansion chamber (17) defined by an annular region which is comprised between said casing (2) and said first damping ele-

ment (10) and which is moreover axially delimited by a first wall (17a) and a second wall (17b).

8. The device according to any one of Claim 3 to 7, **characterized in that** it comprises a second damping element (18), set inside said casing (2), downstream of said filter element (5), said damping element (18) being coaxial to said centroidal axis of symmetry (A).
9. The device according to Claim 7, **characterized in that** said second damping element (18) is a perforated-plug element with high perforation density.

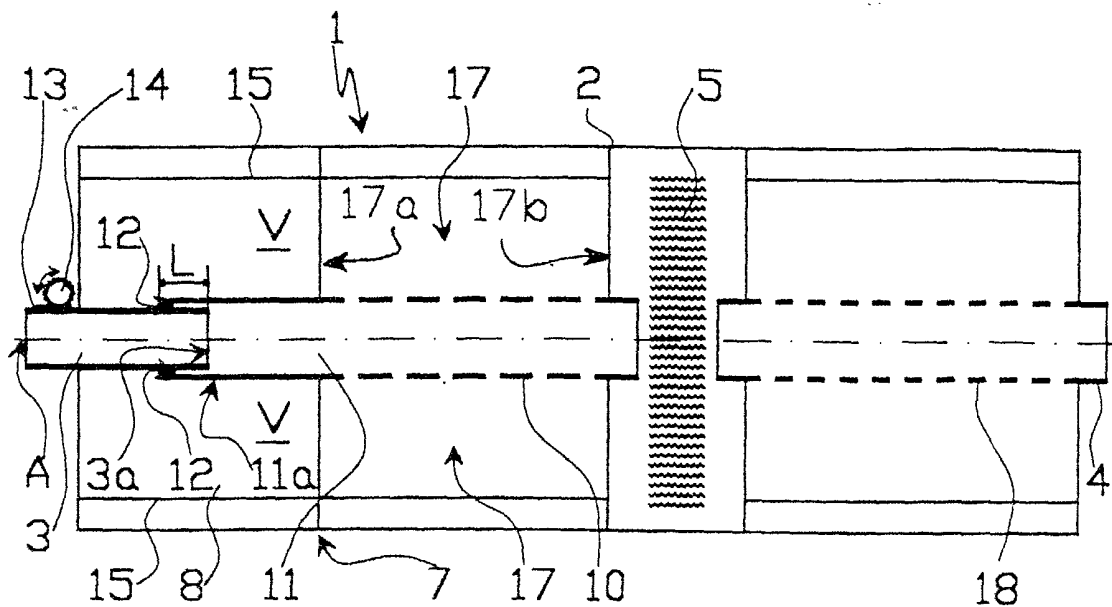


Fig. 1

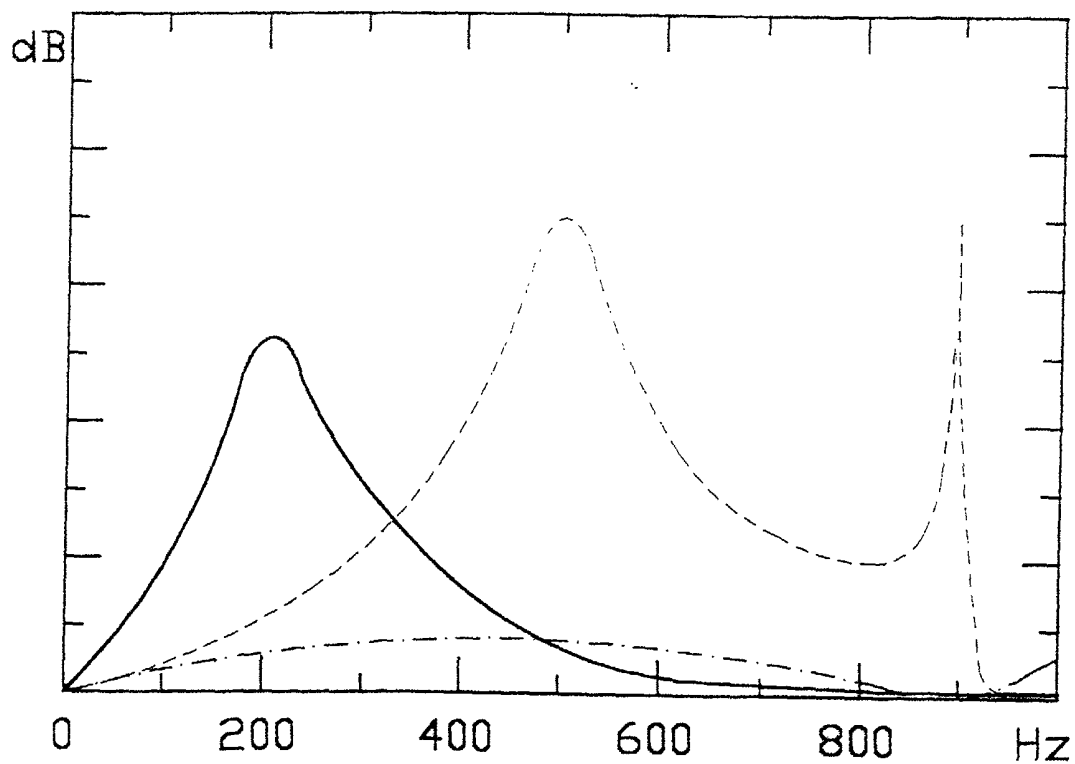


Fig. 2



European Patent
Office

EUROPEAN SEARCH REPORT

Application Number
EP 02 00 8733

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.7)
X	GB 1 507 247 A (DBA SA) 12 April 1978 (1978-04-12) * page 1, line 31 - line 34 * * page 1, column 93 - page 2, column 18; figure 1 *	1-4,7	F02M35/14 F02M35/12 F02M35/00 F02B27/02
X	US 6 048 386 A (GILLINGHAM GARY R ET AL) 11 April 2000 (2000-04-11)	1-3	
Y	* column 6, line 41 - line 67; figure 18 *	4,5	
X	US 2 553 326 A (MANNING WILLIS L) 15 May 1951 (1951-05-15)	1-3,7-9	
Y	* column 1, line 38 - column 2, line 41; figures 1,4 *	4	
X	PATENT ABSTRACTS OF JAPAN vol. 014, no. 157 (M-0955), 27 March 1990 (1990-03-27) & JP 02 019644 A (TOYODA SPINNING & WEAVING CO LTD), 23 January 1990 (1990-01-23) * abstract; figure 1 *	1	
Y	DE 196 41 715 A (MANN & HUMMEL FILTER) 16 April 1998 (1998-04-16)	5	
A	* page 1, line 3 - line 17; figure 1 *	1	
E	EP 1 156 205 A (SIEMENS CANADA LTD) 21 November 2001 (2001-11-21) * column 1, line 10 - line 21; claim 1; figures 1,4 *	1,2,4	
The present search report has been drawn up for all claims			
Place of search MUNICH		Date of completion of the search 26 June 2002	Examiner Zebst, M
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

EPO FORM 1503 03.82 (P04C01)

**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 02 00 8733

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

26-06-2002

Patent document cited in search report		Publication date	Patent family member(s)	Publication date
GB 1507247	A	12-04-1978	FR 2307142 A1	05-11-1976
			DE 7635516 U1	24-02-1977
US 6048386	A	11-04-2000	US 5792247 A	11-08-1998
			AT 210784 T	15-12-2001
			AU 722515 B2	03-08-2000
			AU 2743797 A	19-11-1997
			BR 9709742 A	10-08-1999
			CA 2252548 A1	06-11-1997
			CN 1220720 A , B	23-06-1999
			DE 69709082 D1	24-01-2002
			DE 69709082 T2	02-05-2002
			EP 0894190 A1	03-02-1999
			JP 2000509458 T	25-07-2000
			PL 329559 A1	29-03-1999
			WO 9741345 A1	06-11-1997
			ZA 9703640 A	26-10-1998
US 2553326	A	15-05-1951	NONE	
JP 02019644	A	23-01-1990	NONE	
DE 19641715	A	16-04-1998	DE 19641715 A1	16-04-1998
			WO 9815727 A1	16-04-1998
			EP 1012458 A1	28-06-2000
			JP 2001501706 T	06-02-2001
			US 6105546 A	22-08-2000
EP 1156205	A	21-11-2001	EP 1156205 A2	21-11-2001
			US 2001035096 A1	01-11-2001