US 20050167192A1

(19) **United States**

(12) **Patent Application Publication** (10) **Pub. No.: US 2005/0167192 A1**

**Simon** (43) **Pub. Date: Aug. 4, 2005**

(54) **SILENCER FOR A MOTOR VEHICLE EXHAUST SYSTEM, AND ITS METHOD OF MOUNTING**

(75) Inventor: **Jean-Michel Simon**, Chatillon (FR)

Correspondence Address:
**MICHAEL BEST & FRIEDRICH, LLP**
**100 E WISCONSIN AVENUE**
**MILWAUKEE, WI 53202 (US)**

(73) Assignee: **Hutchinson**, Paris (FR)

(21) Appl. No.: **11/036,554**

(22) Filed: **Jan. 14, 2005**

(30) **Foreign Application Priority Data**

Jan. 30, 2004 (FR) ..... 0400894

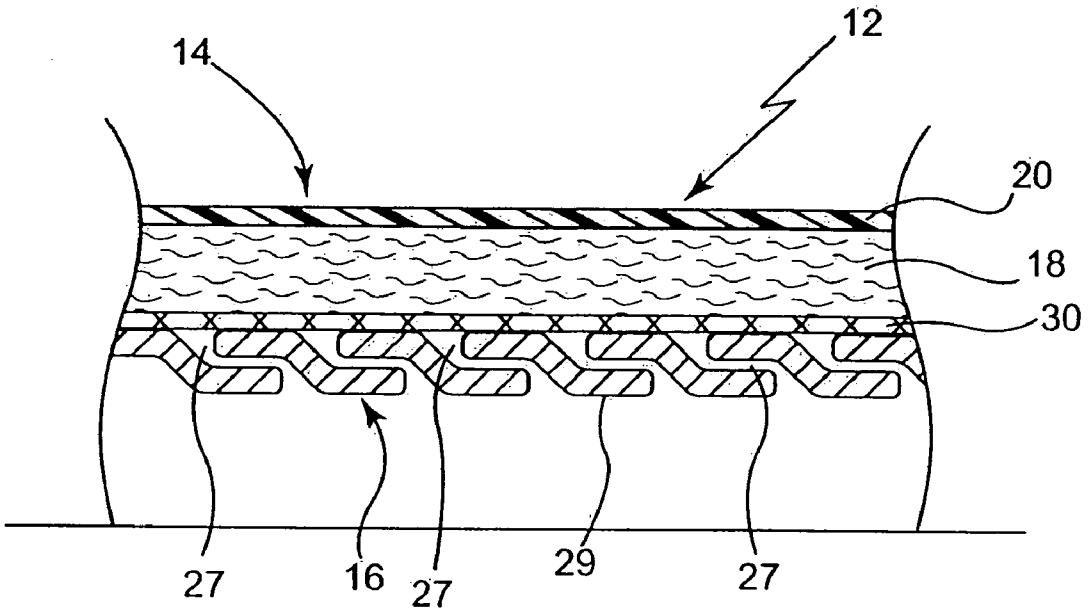
**Publication Classification**

(51) **Int. Cl.**[7] ..... **F01N 1/24**; F01N 1/10

(52) **U.S. Cl.** ..... **181/256**; 181/252; 181/222

(57) **ABSTRACT**

A silencer for a vehicle engine exhaust system, wherein the silencer is constituted by at least one duct which acts as a guide for exhaust gas and as an acoustic attenuator for exhaust noise, and which comprises at least one porous internal metal tubular element, intermediate thermal and acoustic lagging, and a leaktight outer covering of polymer material, and wherein the outer covering is connected in leaktight manner to two tubular metal connection devices via two metal caps.



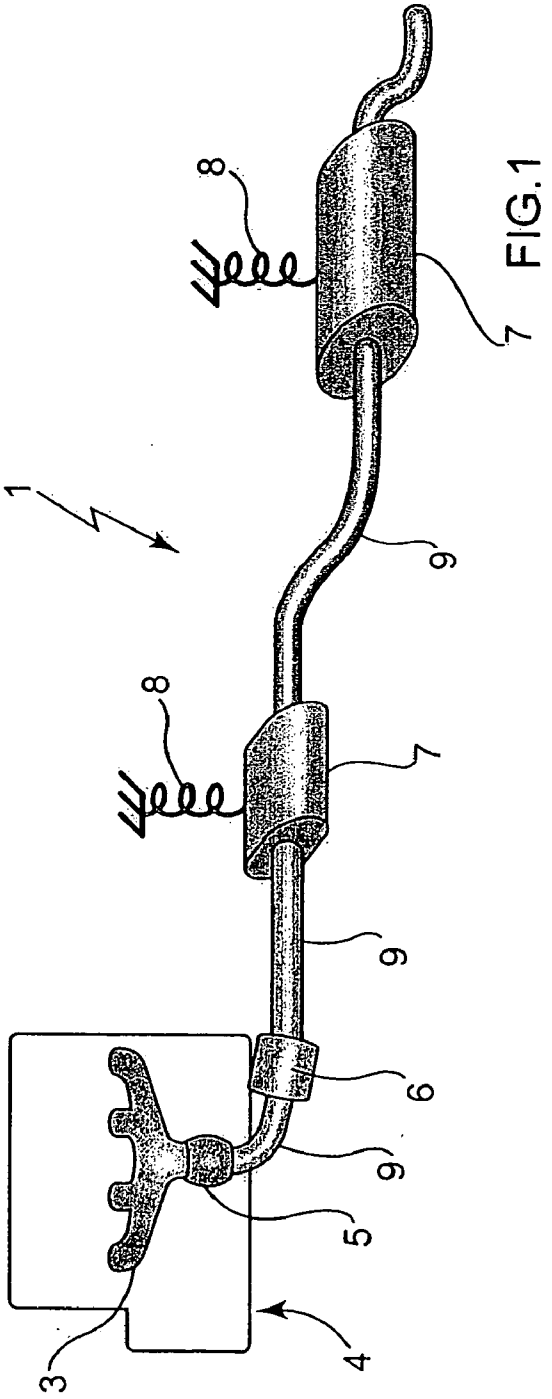



FIG.1

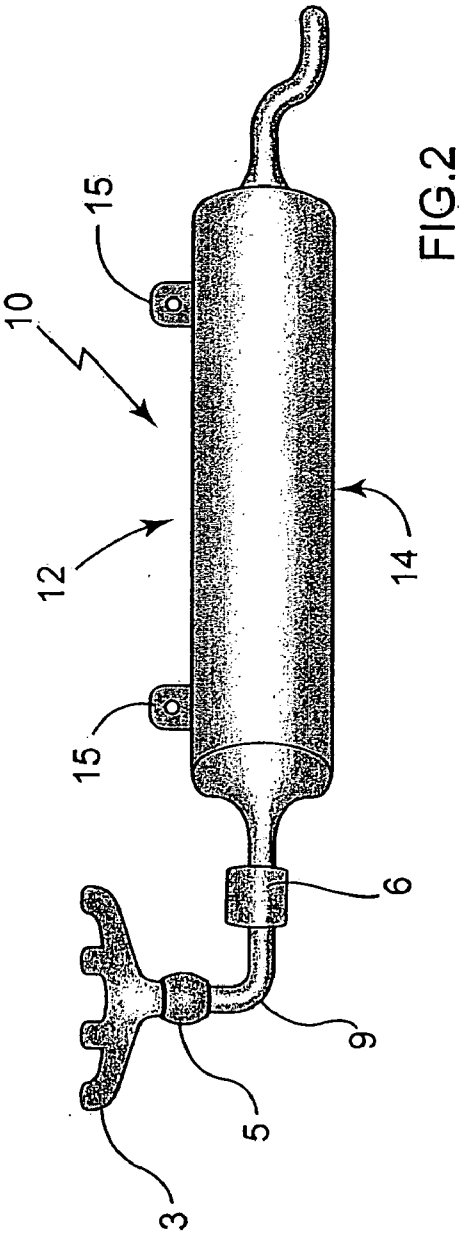



FIG.2

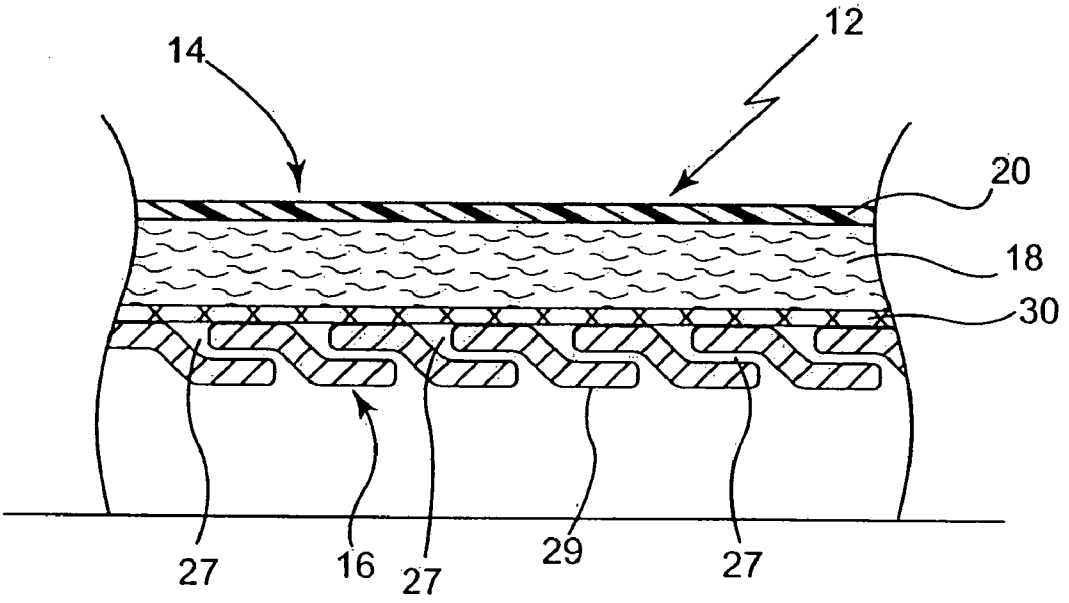



FIG.3

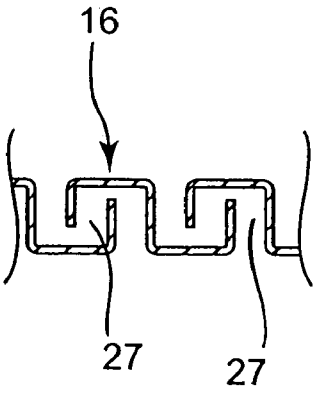



FIG.4d

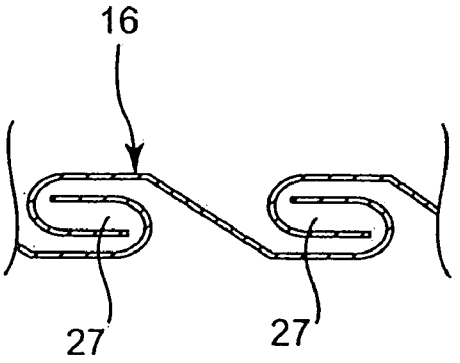



FIG.4e

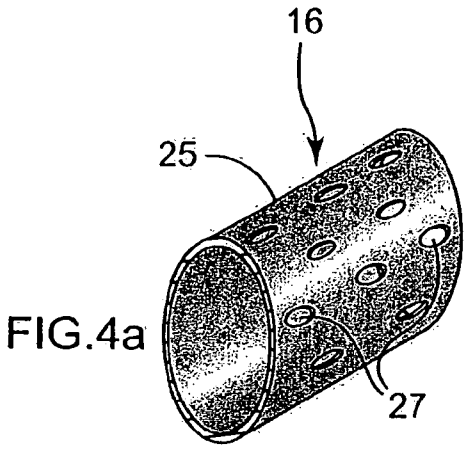



FIG.4a

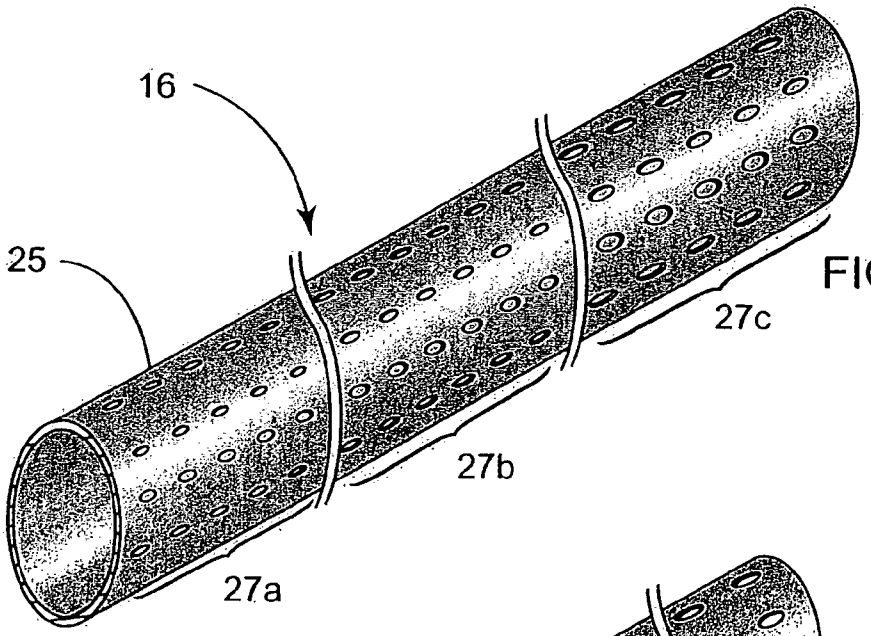



FIG.4b

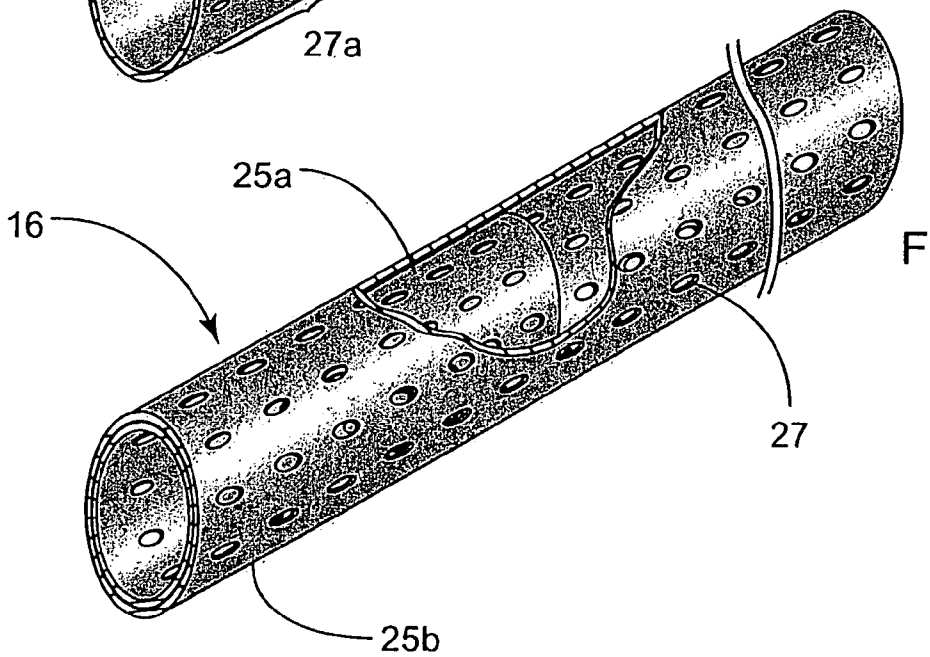



FIG.4c

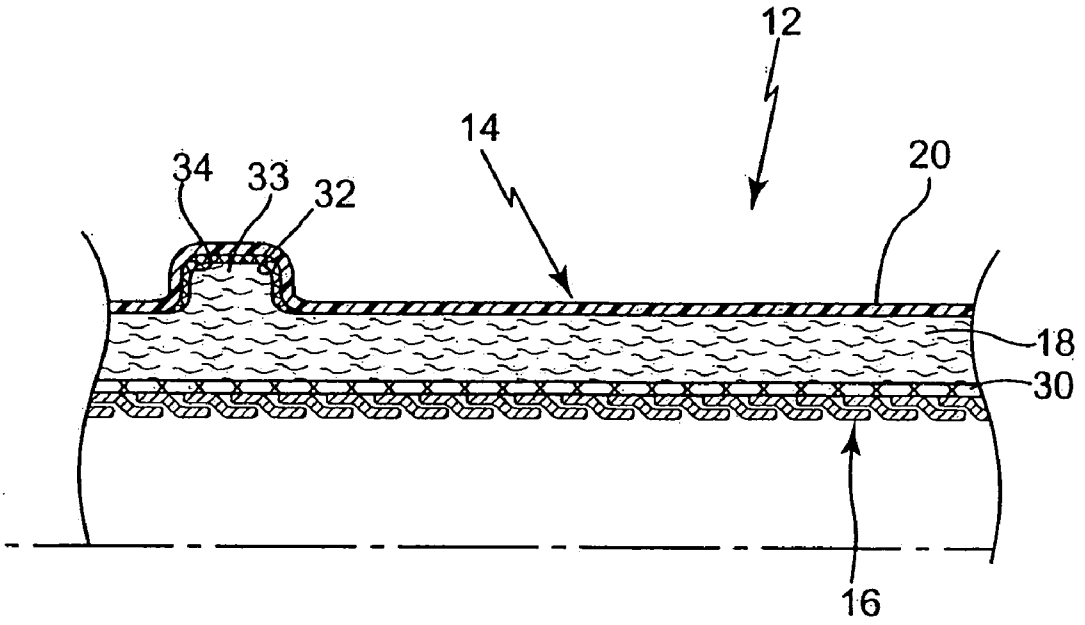



FIG.5

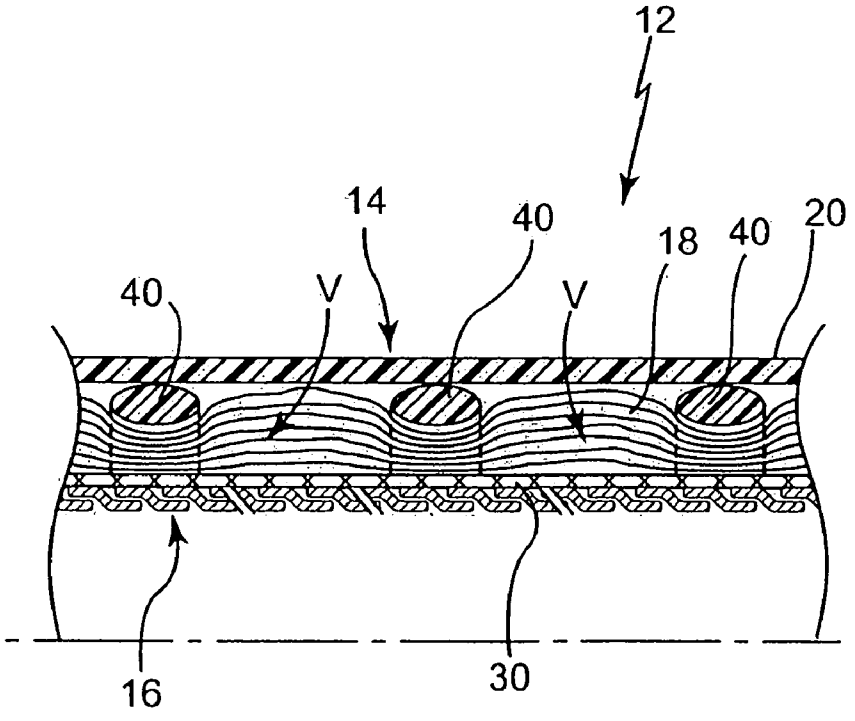
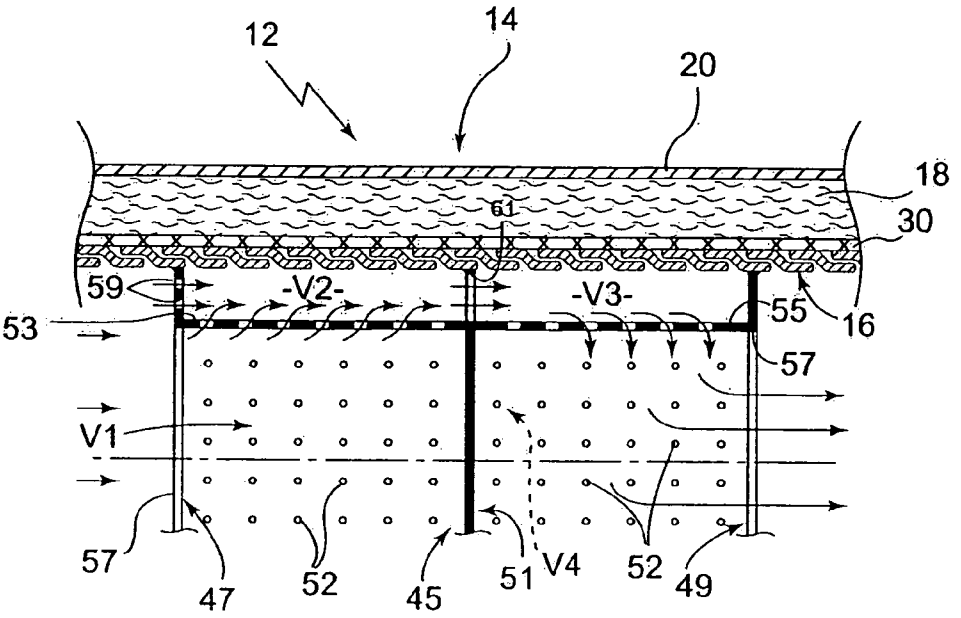



FIG.6

FIG.7



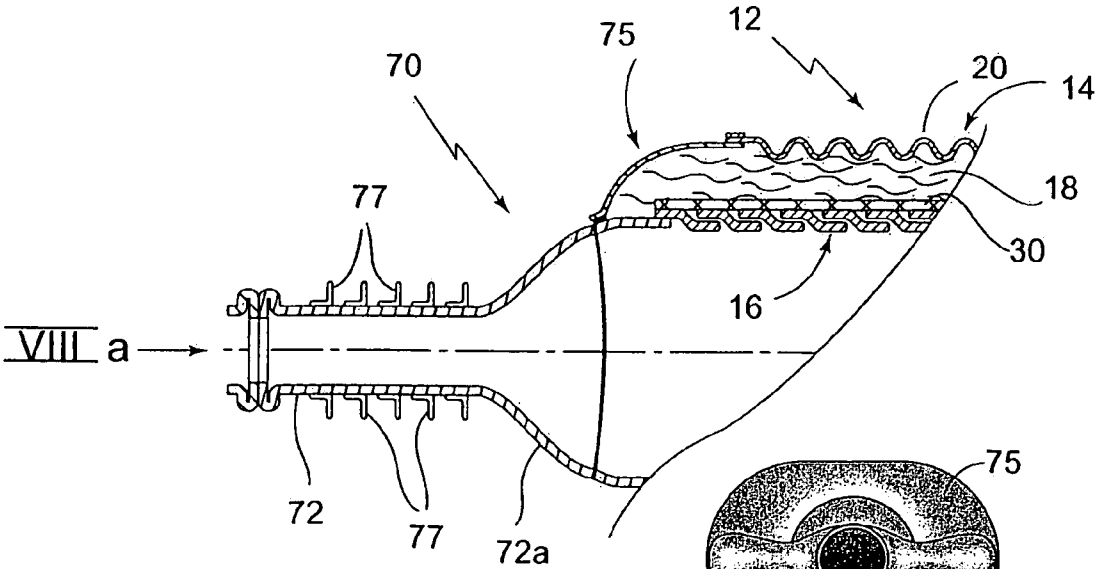




FIG.8

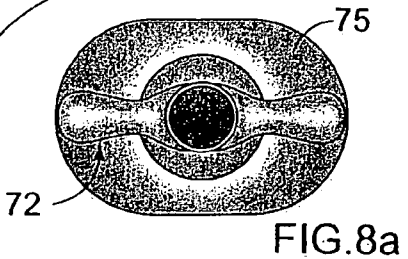



FIG.8a

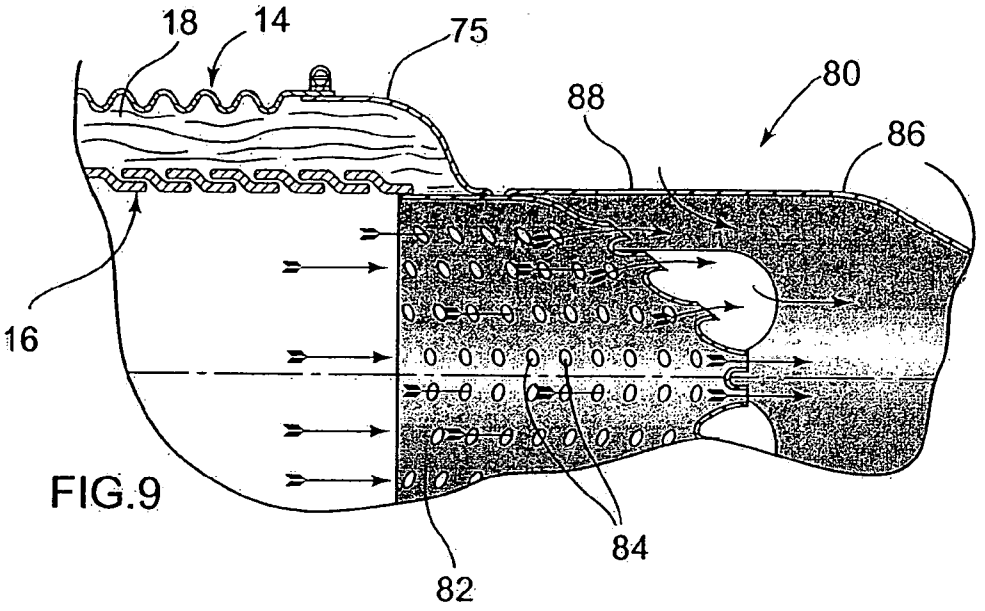



FIG.9

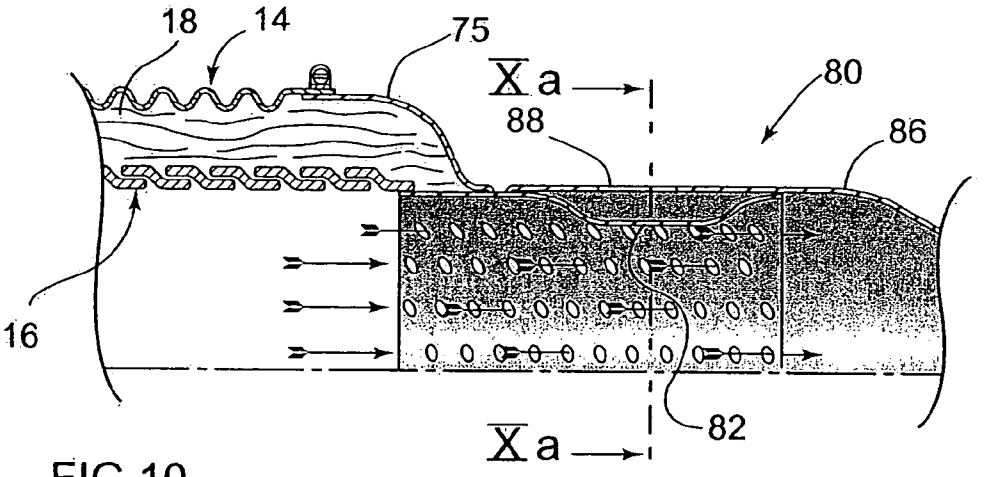



FIG.10

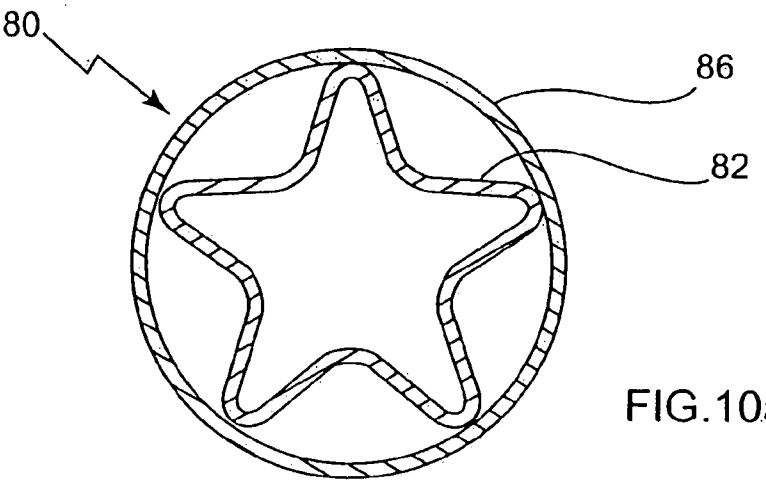



FIG.10a

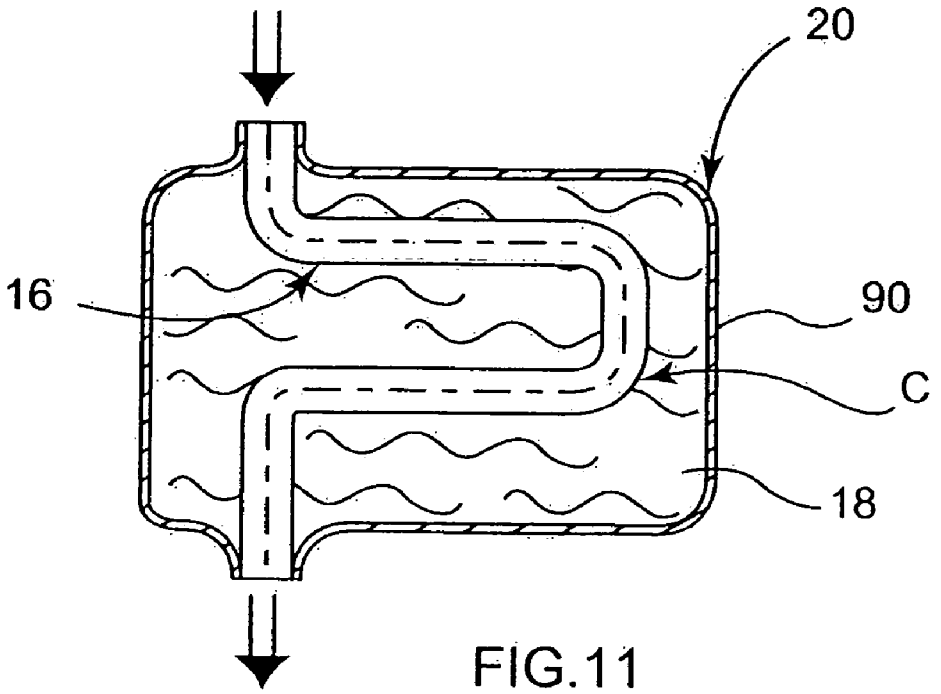



FIG.11

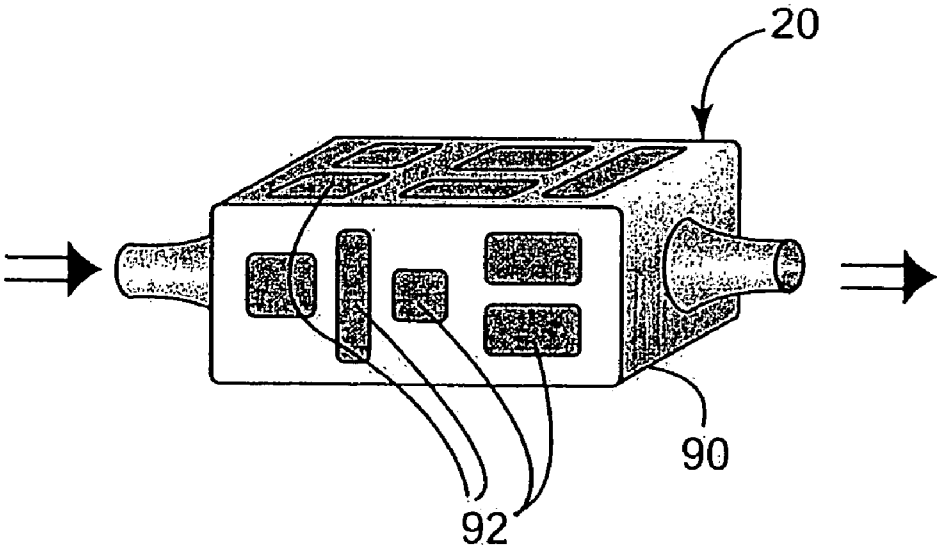



FIG.12

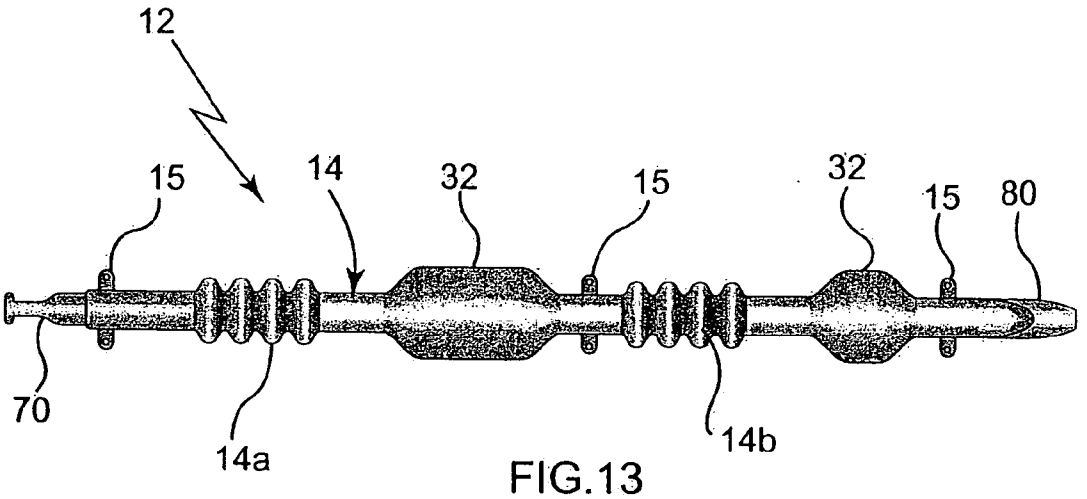



FIG.13

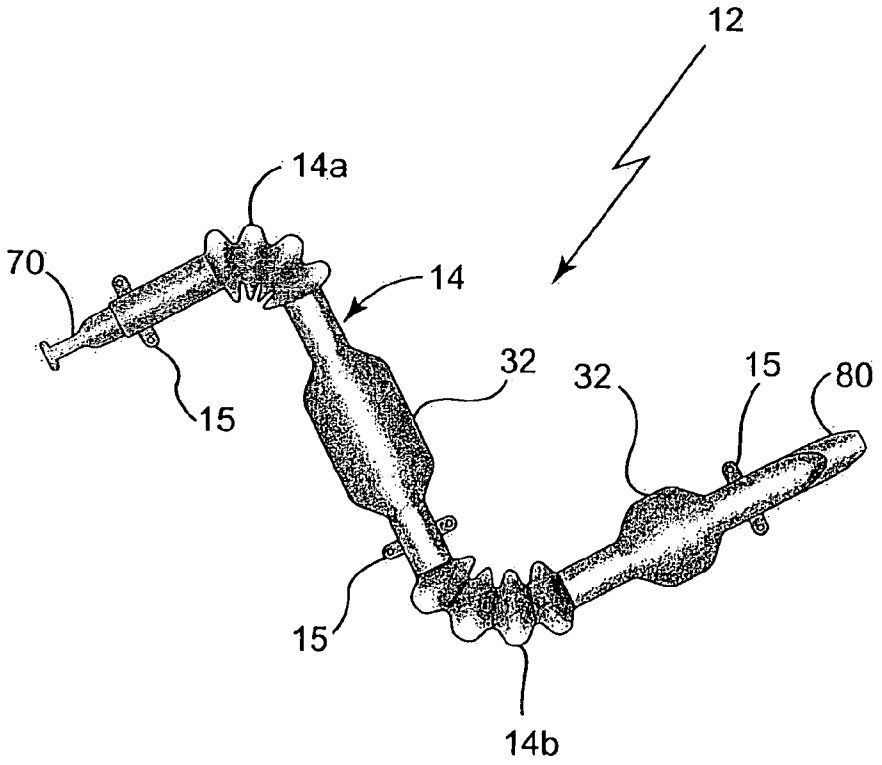



FIG.14

# SILENCER FOR A MOTOR VEHICLE EXHAUST SYSTEM, AND ITS METHOD OF MOUNTING

[0001] The invention relates to a silencer for a motor vehicle exhaust system, and also to its method of mounting.

## BACKGROUND OF THE INVENTION

[0002] In the prior art, an exhaust system comprises in succession, going away from the exhaust manifold of the power unit: a decoupling hose, a catalytic converter, and/or a particle filter, and often two silencers. An exhaust system silencer is of large volume (h=150 millimeters (mm)×L=400 mm×w=200 mm, for example) and it is fixed to the vehicle body by resilient straps, thereby leading to considerable size constraints.

## OBJECTS AND SUMMARY OF THE INVENTION

[0003] An object of the invention is to devise an exhaust system having a novel type of silencer making it possible to reduce weight, cost, and size in order to mitigate the drawbacks of a conventional exhaust system.

[0004] To this end, the invention provides a silencer for a vehicle engine exhaust system, wherein the silencer is constituted by at least one duct which acts as a guide for exhaust gas and as an acoustic attenuator for exhaust noise, and which comprises at least one porous internal metal tubular element, intermediate thermal and acoustic lagging, and a leaktight outer covering of polymer material, and wherein the outer covering is connected in leaktight manner to two tubular metal connection devices via two metal caps.

[0005] The internal metal tubular element may be constituted by a flat spring with overlapping turns, by a sheet metal tube with single or double seam joints, or by a flexible or rigid metal tube, each of which elements may be pierced with openings for acoustic reasons.

[0006] Advantageously, the internal tubular element may be coated in a refractory fabric possessing a certain degree of porosity, the refractory fabric possibly being made of ceramic, basalt, or glass fibers.

[0007] The duct, which may be flexible, may also include leaktight annular volumes arranged longitudinally in the thermal and acoustic lagging, each leaktight intermediate volume being defined by two compression rings, each compression ring being resilient and made of silicone, for example.

[0008] The duct may also include acoustic baffles interposed in the internal tubular element.

[0009] In general, in order to reduce the temperature of exhaust gases, a tubular metal connection device can be placed at the entrance to the duct, the device presenting external and/or internal cooling fins, and/or a diffuser-forming device may be placed at the exit from the duct.

[0010] In an embodiment of the silencer in accordance with the invention, the outer covering of the duct may form a box having the internal metal element passing therethrough, the thermal and acoustic lagging filling said box in which the internal metal element may form at least one bend.

[0011] Advantageously, the wall of the box presents at least one resonance surface in the form of a membrane, for example, having resonant frequency(ies) corresponding to certain frequencies of the frequency spectrum that is to be attenuated.

[0012] The invention also provides a method of mounting a silencer of the invention in a motor vehicle exhaust system, the method consisting in manufacturing, storing, and transporting the silencer in rectilinear shape, and in deforming it to comply with a given geometrical shape at its mounting site using the corrugations formed by the outer covering of the duct.

## BRIEF DESCRIPTION OF THE DRAWINGS

[0013] Other advantages, characteristics, and details of the invention appear from the additional description below made with reference to the accompanying drawings, given purely by way of example, and in which:

[0014] **FIG. 1** is a perspective view of a prior art exhaust system, mentioned in the introduction;

[0015] **FIG. 2** is a perspective view of an exhaust system including a silencer in accordance with the invention;

[0016] **FIG. 3** is a fragmentary longitudinal section view of an embodiment of the **FIG. 2** silencer with a flexible duct comprising at least one internal tubular element, thermal and acoustic lagging, and an outer covering;

[0017] **FIGS. 4*a*** to **4*e*** are diagrams showing variant embodiments of the internal tubular element of the flexible duct of **FIG. 3**;

[0018] **FIG. 5** is a section view of an embodiment of the external covering of the duct;

[0019] **FIG. 6** is a fragmentary longitudinal section view showing compression rings mounted in the thermal and acoustic lagging of the duct of **FIG. 3**;

[0020] **FIG. 7** is a fragmentary longitudinal section view showing acoustic baffles interposed in the internal tubular element of the duct of **FIG. 3**;

[0021] **FIG. 8** is a fragmentary longitudinal section view of a device enabling exhaust gas to enter into the **FIG. 3** duct;

[0022] **FIG. 8*a*** is a view seen looking along arrow VIIIa of **FIG. 8**;

[0023] **FIG. 9** is a longitudinal section view of a device enabling exhaust gas to exit from the duct of **FIG. 3**;

[0024] **FIG. 10** shows a variant embodiment of **FIG. 9**;

[0025] **FIG. 10*a*** is a section view on line Xa-Xa of **FIG. 10**;

[0026] **FIG. 11** is a diagram showing another embodiment of the duct of the invention;

[0027] **FIG. 12** is a perspective view of **FIG. 11**; and

[0028] **FIGS. 13 and 14** are perspective views for showing the method of mounting a silencer of the invention.

## MORE DETAILED DESCRIPTION

[0029] The exhaust system **1** shown in **FIG. 1** shows the state of the art mentioned in the introduction, the system **1** comprising in succession, from a multitube exhaust mani-

fold **3** at the outlet from a power unit **4**: a decoupling hose **5**; a catalytic converter **6**; and two rigid silencers **7** secured to the vehicle body by resilient straps **8**; and interconnected by tubes **9** of stainless steel.

[**0030**] In the exhaust system **10** of the invention and as shown in **FIG. 2**, the two silencers **7** have been eliminated and replaced by at least one silencer **12** constituted by a duct **14** which is fastened by rigid fastening tabs **15** to the body of the vehicle and which acts as a guide for exhaust gas and as an acoustic attenuator for exhaust noise, as described below with reference to FIGS. **2** to **9**.

[**0031**] In an embodiment of the invention shown in **FIG. 3**, the duct **14** is constituted by at least one internal tubular element **16** which is porous, thermal and acoustic lagging **18**, and a flexible and leakproof external covering **20** of elastomer material that withstands high temperature, the covering **20** possibly being made out of a thermoplastic material such as PA **66**, or an elastomer material such as Vamac®, or silicone, for example.

[**0032**] In general, the duct **14** is constituted by at least one internal tubular element **16** of flexible or rigid type which is preferably made of metal so as to be capable of withstanding the temperature of exhaust gas, and which is porous, in particular for acoustic reasons. The internal tubular element **16** is made to be porous by piercing openings through it over substantially its entire length.

[**0033**] As an example shown in **FIG. 4***a*, the internal tubular element **16** is constituted by a metal tube **25** pierced by openings **27**. Advantageously, the openings **27** can be formed by a plurality of series of openings, e.g. three series **27***a*, **27***b*, and **27***c* which are of flow sections or diameters that increase going in the flow direction of the exhaust gas, in particular to avoid any risk of the exhaust gas flowing in the reverse direction through the lagging **18**, and as shown in **FIG. 4***b*. These three series of openings **27***a*, **27***b*, and **27***c* may have diameters of 1 mm, 2 mm, and 3 mm respectively, for example. In a first variant embodiment shown in **FIG. 4***c*, the internal tubular element **16** is constituted by two concentric tubes, an inner tube **25***a* and an outer tube **25***b*, the inner tube **25***a* extending over a fraction only of the length of the silencer, for example, e.g. over 5% to 30%, so as to create interference suitable for canceling the sound-waves from the flow of exhaust gases. In a second variant embodiment of the invention, the internal tubular element **16** is made of sheet metal with single or double seam joints (**FIG. 4***d*, **FIG. 4***e*) or by a spring having overlapping turns (**FIG. 3**), all of which elements present communication passages independently of any additional openings that may be pierced in the same manner as for the metal tubes of **FIGS. 4***a* or **4***b*.

[**0034**] In the embodiment of a silencer of the invention that is shown in **FIG. 3**, the internal tubular element **16** is made in the form of a flat spring **29** having overlapping turns, however the element **16** could be replaced by an element as shown in any of the embodiments of **FIGS. 4***a* to **4***e*. Advantageously, a refractory fabric **30** can be wound around all or part of the internal tubular element **16**, said fabric presenting sufficient porosity to enable the lagging **18** to damp acoustic waves, while limiting any direct passage of exhaust gas through the lagging **18** so as to avoid damaging the outer covering **20**. The fabric **30** may be made of ceramic, basalt, or glass fibers, for example.

[**0035**] In the embodiment shown in **FIG. 5**, the duct **14** may present at least one outwardly-extending projection **32** formed in its outer covering **20** to create an additional volume **33** that is filled with the material constituting the lagging **18**. Advantageously, an absorbent lining **34** having a very low index of reflection can be received against the inside wall of the projection **32** so as to obtain better noise absorption. This is made possible by the low temperature level in the vicinity of the projection **32**, and would be impossible to do with a metal silencer of the prior art. The lining **34** may be made of a cellular silicone foam, for example.

[**0036**] In the embodiment shown in **FIG. 6**, compression rings **40** are provided in the lagging **18** to compress it, thereby defining a plurality of volumes V that are matched to the frequencies that are to be countered. These rings **40** are resilient, being spaced apart regularly from one another, e.g. being made of silicone, and they bear against the outer covering **20**. Thus, compressing the insulating material on one side and pressing against the outer covering **30** on the other side, they serve to define a leaktight volume V which acts as an acoustic resonant volume. Such rings **40** thus create an incompressible zone suitable for supporting the weight of the internal tubular element **16** without any risk of the insulating material suffering creep.

[**0037**] In the embodiment shown in **FIG. 7**, acoustic baffles **45** are interposed inside the internal tubular element **16** of the duct **14**. A baffle **45** may be constituted by an assembly of three metal disks, two end disks comprising an upstream disk **47** and a downstream disk **49**, and a middle disk **51**, all three disks being disposed perpendicularly to the flow direction of the exhaust gases, and two connecting metal tubes **53** and **55** pierced by holes **52** and mounted coaxially inside the internal tubular element **16**, being of smaller diameter. More precisely, the upstream end disk **47** presents a central opening **57** having the diameter of the two connection tubes **53** and **55**, and openings **59** distributed around the central opening, while the downstream end disk **49** has only one central opening **57** of the diameter of the two connection tubes **53** and **55**. The middle disk **51** is solid in its central portion so as to prevent direct communication between the two connection tubes **53** and **55**, however it does present openings **61** in its periphery. This defines a first volume $V_1$ inside the connection tube **53**, a second volume $V_2$ that is annular around the connection tube **53**, a third volume $V_3$ that is annular around the connection tube **55**, and a fourth volume $V_4$ inside the connection tube **55**. Thus, the exhaust gas penetrates directly firstly into the first volume $V_1$ via the central opening **57** in the upstream disk **47**, and then into the second volume $V_2$ through the holes **52** in the connection tube **53**, and secondly into the volume $V_2$ through the holes **59** in the upstream disk **47**. The exhaust gas passes from the second volume $V_2$ to the third volume $V_3$ through the openings **61** in the middle disk **51**, and then penetrates into the fourth volume $V_4$ through the openings **52** in the connection tube **55** prior to escaping from the baffle **45** via the central opening **57** in the downstream disk **49**. A plurality of baffles **45** may be interposed inside the internal tubular element **16** of the duct **14**.

[**0038**] **FIG. 8** shows an embodiment of a connection device **70** mounted at the entrance to the duct **14**. In general, the exit from the catalytic converter **6** is provided by a metal tubular element **72**, e.g. made of stainless steel, whose

downstream end **72***a* is flared so as to connect to the duct **14** which is of diameter greater than that of the tubular element **72**. The internal tubular element **16** is welded to the flared end **72***a* of the tubular element **72**, while the outer covering **20** of the duct **12** is connected by means of a long and thin-walled metal cap **75** that serves to protect the outer covering **20** against high temperatures. Advantageously, external and/or internal cooling fins **77** can be provided on or in the tubular element **72** in order to cool the exhaust gas prior to entry into the duct **14** of the silencer **12**, and the outer covering **20** may be corrugated. To further encourage heat exchange and to reduce the temperature of the exhaust gas penetrating into the duct **14**, the tubular element **72** can be flattened, giving it an undulating or corrugated shape, as can be seen in **FIG. 8***a*.

[**0039**] In general, the exhaust gas must be rejected to the atmosphere at a temperature of less than 200° C., for example, whereas on the entry to the duct **14** it may be at a temperature of about 500° C. When the cooling fins **77** of the connection device **70** at the entrance of the duct **14** (**FIG. 8**) are found to be insufficient, it is possible to mount a diffuser-forming exit device **80** made of metal at the outlet from the duct **14**. This exit device **80**, as shown in **FIG. 9**, may comprise at least one element **82** of generally conical shape that is pierced by holes **84**, and a tubular exit element **86** which surrounds and extends the element **82**. Thus, the exhaust gas leaves via the holes **84** to penetrate into the tubular exit element **86** which presents at least one opening **88** in its wall so as to allow ambient air to enter, thereby encouraging the expulsion of exhaust gases at moderate temperature.

[**0040**] **FIG. 10** shows another embodiment of the exit device **80** of **FIG. 9**. This exit device **80** also has an element **82**, but this time it is star-shaped, and it has an exit element **86** which surrounds and extends the element **82**, having at least one opening **88** in its wall so as to allow air to enter.

[**0041**] In a variant embodiment of the invention as shown in **FIG. 11**, the outer covering **20** of the duct **14** can be made over at least a portion of the duct in the form of a leaktight box **90** having the internal metal tubular element **16** passing therethrough coated in its refractory fabric **30**. The box **90** is made of two portions that are assembled together after the internal metal element **16** has been inserted, the box **90** being filled with the thermal and acoustic lagging **18**. The internal metal element **16** may form at least one C-shaped bend inside the box **90** so as to increase the acoustic insulation of the duct **14**.

[**0042**] Advantageously, and as shown in **FIG. 12**, the wall of the box **90** may include at least one resonant surface **92** in the form of a diaphragm, for example, having one or more resonant frequencies corresponding to certain frequencies in the frequency spectrum that is to be attenuated. Such a surface **92**, on being excited, is set into vibration, thereby dissipating energy in such a manner as to contribute effectively to acoustically insulating the duct **14**.

[**0043**] **FIGS. 13 and 14** show a method of mounting a silencer **12** of the invention in an exhaust system of a motor vehicle. In general, a silencer **12** is manufactured, stored, and transported in a rectilinear shape. Then, on the site where the silencers **12** are mounted, each silencer is deformed into the geometrical configuration it is to occupy prior to being fastened to the vehicle body via its rigid fastening tabs **15**. In the example shown, the silencer **12** presents at least two series of corrugations **14***a* and **14***b*, and it is via these corrugations **14***a* and **14***b* that is it possible to bend the silencer **12**.

[**0044**] In the examples described above, the duct **14** presents a porous internal metal element **16** extending over substantially its entire length, however the duct **14** could also be made as a plurality of portions assembled together in pairs by substantially smooth tubular metal elements connected to two adjacent porous metal elements **16**, where a smooth element is suitable for being bent and is optionally covered in a refractory fabric **30**, in lagging **18**, and in the outer covering **20**.

What is claimed is:

**1**. A silencer for a vehicle engine exhaust system, wherein the silencer is constituted by at least one duct which acts as a guide for exhaust gas and as an acoustic attenuator for exhaust noise, and which comprises at least one porous internal metal tubular element, intermediate thermal and acoustic lagging, and a leaktight outer covering of polymer material, and wherein the outer covering is connected in leaktight manner to two tubular metal connection devices via two metal caps.

**2**. A silencer according to claim 1, in which the duct is flexible.

**3**. A silencer according to claim 1, in which the internal metal tubular element is constituted by a flat spring having overlapping turns.

**4**. A silencer according to claim 1, in which the internal metal tubular element is constituted by a sheet metal tube with single or double seam joints.

**5**. A silencer according to claim 1, in which the flexible or rigid internal metal tubular element is pierced by openings.

**6**. A silencer according to claim 5, in which the openings are of diameter that increases in the flow direction of the exhaust gas.

**7**. A silencer according to claim 6, in which the openings are subdivided into a plurality of series of openings, the openings in each series having substantially the same diameter.

**8**. A silencer according to claim 5, in which the internal metal tubular element is constituted by at least two concentric tubes, an inner tube and an outer tube, both pierced by openings.

**9**. A silencer according to claim 8, in which the inner metal tube extends over a portion only of the total length of the silencer.

**10**. A silencer according to claim 1, in which the internal tubular element is covered in a refractory fabric presenting a degree of porosity.

**11**. A silencer according to claim 10, in which the refractory fabric is made of ceramic, basalt, or glass fibers.

**12**. A silencer according to claim 1, in which the outer covering of the duct is made on the basis of a thermoplastic material such as polyamide **66**, or on the basis of an elastomer material such as Vamac®, or a silicone.

**13**. A silencer according to claim 1, in which the outer covering of the duct is formed by a blow extrusion operation.

**14**. A silencer according to claim 1, in which leaktight annular volumes are formed that are spaced apart longitudinally in the thermal and acoustic lagging.

**15**. A silencer according to claim 14, in which each leaktight intermediate volume in the thermal and acoustic lagging is defined by two compression rings.

**16**. A silencer according to claim 15, in which each compression ring is resilient and made of silicone, for example.

**17**. A silencer according to claim 1, in which acoustic baffles are interposed in the internal tubular element of the flexible duct.

**18**. A silencer according to claim 17, in which an acoustic baffle is constituted by three disks mounted perpendicularly to the exhaust gas flow axis, and by two connection tubes presenting holes that are coaxial with the internal tubular element and that are of smaller diameter.

**19**. A silencer according to claim 1, in which the leakproof outer covering presents at least one outwardly-directed projection to create an additional volume which is filled with the material forming the lagging.

**20**. A silencer according to claim 19, in which the inside wall of the projection is covered in an absorbent lining.

**21**. A silencer according to claim 20, in which the absorbent lining is a cellular silicone foam.

**22**. A silencer according to claim 1, in which the flexible duct has its entrance connected to a flared tubular metal connection device presenting internal and/or external cooling fins to reduce the temperature of the exhaust gas.

**23**. A silencer according to claim 1, in which the flexible duct is connected at its exit to a diffuser-forming device for reducing the exit temperature of the exhaust gas.

**24**. A silencer according to claim 23, in which the diffuser-forming exit device comprises at least one generally conical element that is pierced by holes, and a tubular exit element which surrounds and extends the element, and having a wall that presents at least one opening for enabling ambient air to enter therein.

**25**. A silencer according to claim 23, in which the diffuser-forming exit device comprises at least one star-shaped element and an exit tubular element which surrounds and extends the element, and having a wall that presents at least one opening for allowing ambient air to enter therein.

**26**. A silencer according to claim 1, in which the leakproof outer covering of the silencer forms a box through which the internal metal tubular element passes, the intermediate thermal and acoustic lagging filling said box.

**27**. A silencer according to claim 26, in which the internal metal tubular element forms at least one bend inside the box.

**28**. A silencer according to claim 26, in which the box presents in its wall, at least one surface formed by a resonant membrane which is tuned to at least one frequency in the frequency spectrum to be attenuated.

**29**. A silencer according to claim 1, in which the silencer comprises at least two ducts connected to each other by an optionally bent tubular metal element.

**30**. A silencer according to claim 29, in which the tubular metal element is smooth.

**31**. A method of mounting a silencer as defined in claim 1 in a motor vehicle exhaust system, the method consisting in manufacturing, storing, and transporting the silencer in rectilinear shape, in deforming it to take up a given configuration at the time it is mounted in the exhaust system, and in fastening it to the vehicle body by means of rigid fastening tabs.

**32**. A method according to claim 31, in which the duct is bent at a corrugated zone of the duct.

**33**. A method according to claim 31, in which the leakproof outer covering of the duct is made by a blow extrusion operation.

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