

Nov. 26, 1963

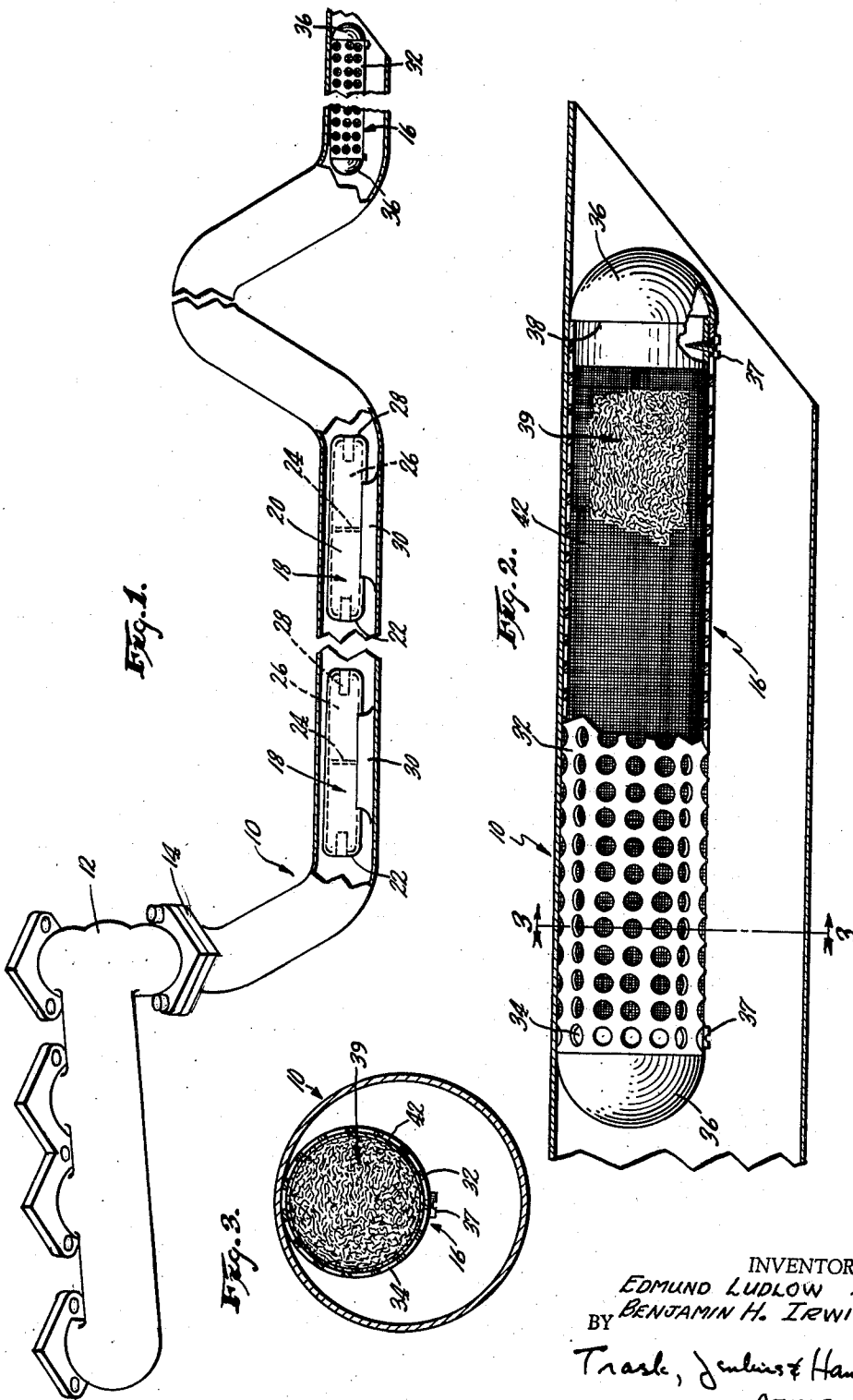
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3,112,007

SILENCING ELEMENT FOR EXHAUST GAS CONDUIT

Filed Nov. 1, 1961

4 Sheets-Sheet 1



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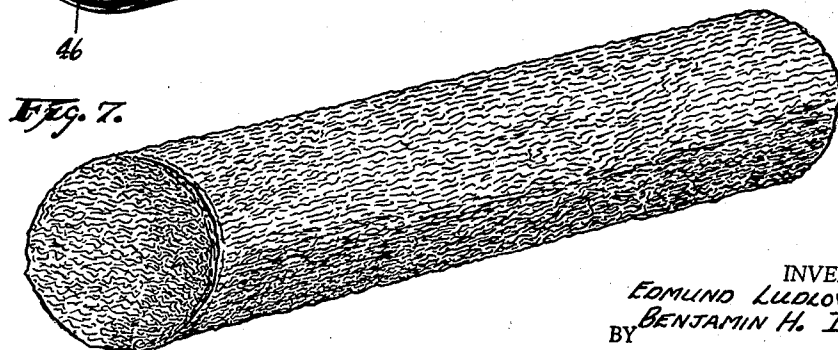
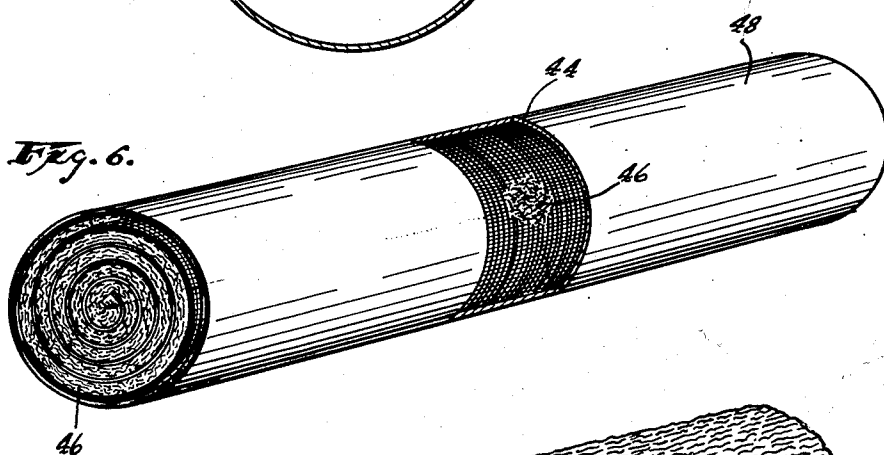
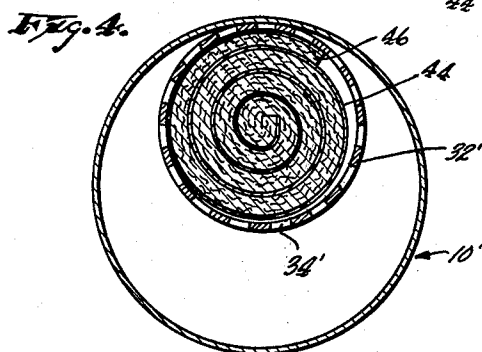
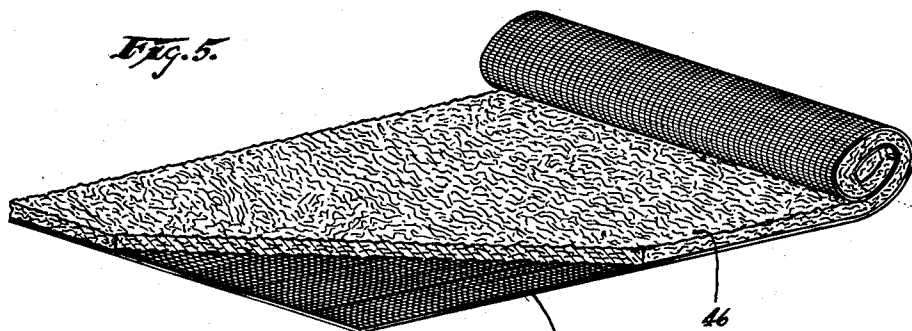
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4 Sheets-Sheet 2



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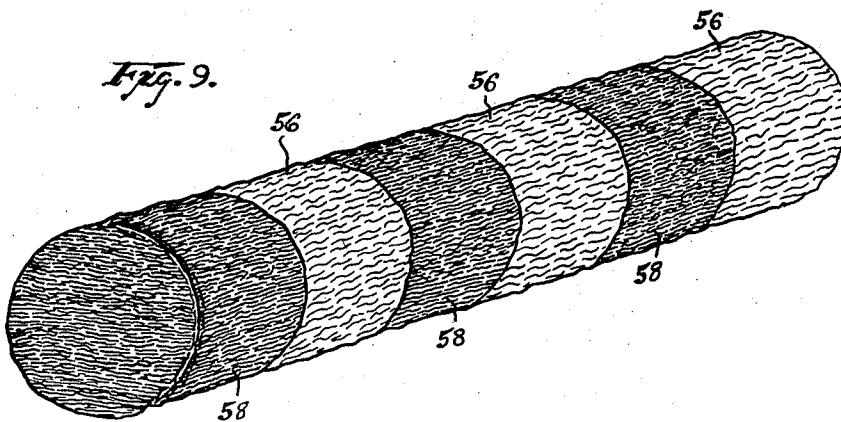
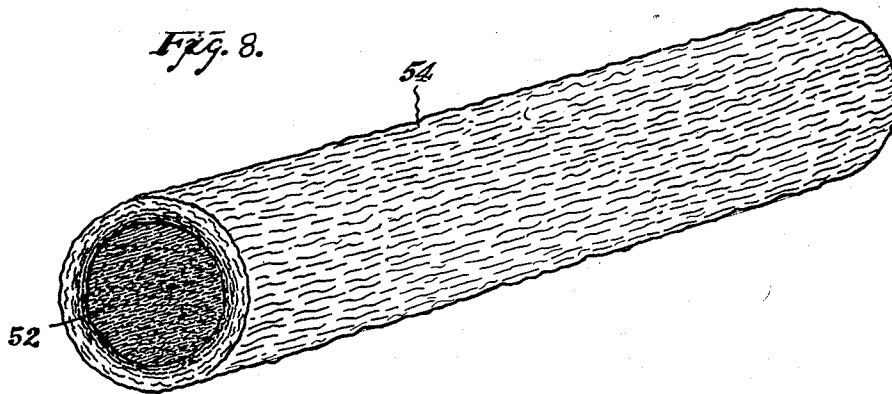
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4 Sheets-Sheet 3



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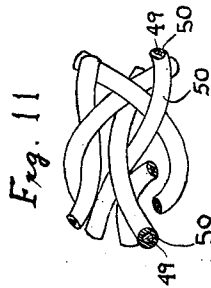
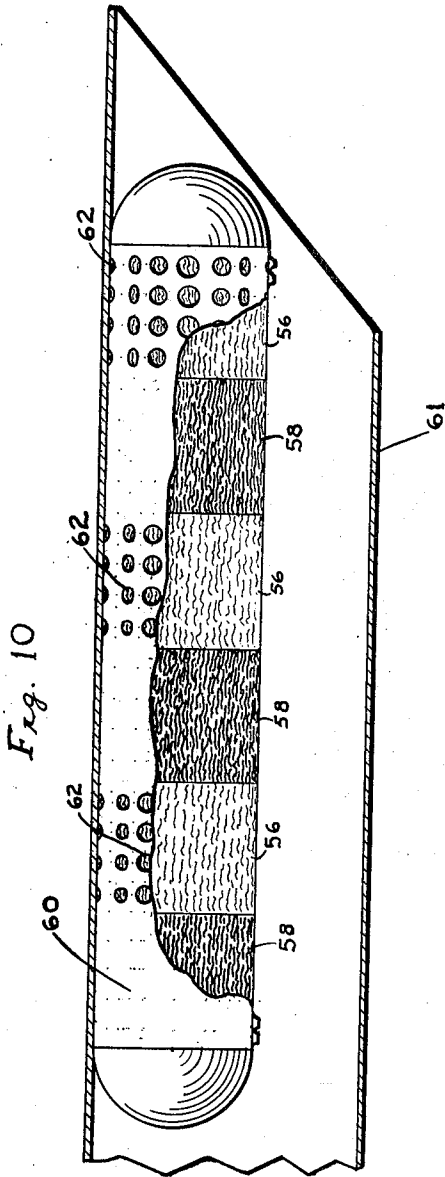
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SILENCING ELEMENT FOR EXHAUST GAS CONDUIT

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4 Sheets-Sheet 4



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3,112,007

SILENCING ELEMENT FOR EXHAUST GAS CONDUIT

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11 Claims. (Cl. 181—59)

This application is a continuation-in-part application of our copending application Serial No. 88,977, filed February 13, 1961. The instant invention relates to a silencing element for a sound attenuating gas conduit, and more particularly to improvements in a silencing element for attenuating high frequency sound waves.

It is an object of our invention to provide a silencing element for a sound attenuating gas conduit which will attenuate high frequency sound waves, which can be easily mounted within such a gas conduit, which will have limited space requirements within such a gas conduit, and which employs a sound attenuating material which can be quickly and easily replaced.

In accordance with our invention, as it is employed in an automotive exhaust system, there is provided an exhaust gas conduit connected to the exhaust manifold of an engine and carrying a plurality of sound attenuating resonators primarily adapted to attenuate those sound wave frequencies below 1,500 cycles per second. Such resonators are disposed in operative association with the gas stream moving through the conduit and are located substantially upstream from the discharge end of said conduit.

The instant invention is concerned with a high frequency silencing element mounted within said conduit immediately adjacent the discharge end thereof. Said element comprises an elongated perforated tube mounted within the conduit and provided at each of its ends with an end closure, with at least the end closure disposed toward the discharge end of the conduit being removably mounted on said tube. A cartridge of a porous sound attenuating material is carried within the tube and is disposed in acoustic coupling relationship with the gases moving through the conduit by the perforations in said tube. Such material may, through the condensation of moisture within the conduit, its being subjected to the turbulence of the gases moving through the conduit, etc. become less porous and/or become broken into small particles which fall through the perforations in the tube, thus reducing its effectiveness. However, by removing the end closure on the tube, a used cartridge of sound attenuating material may be quickly and easily replaced by a new cartridge.

Other objects and features of our invention will become apparent from the more detailed description which follows and from the accompanying drawings, in which:

FIG. 1 is a partially sectioned fragmentary isometric view of a sound attenuating exhaust system having a silencing element embodying our invention mounted therein;

FIG. 2 is an enlarged fragmentary longitudinal section of the portion of the conduit shown in FIG. 1 having our silencing element mounted therein, portions of said silencing element being broken away;

FIG. 3 is a vertical section taken on the line 3—3 of FIG. 2;

FIG. 4 is a vertical section similar to FIG. 3 showing our silencing element mounted in a conduit, but showing a modified form of the sound attenuating cartridge mounted in said element;

FIG. 5 is an isometric view of the sound attenuating cartridge shown in FIG. 4, but showing said cartridge in a partially rolled state prior to insertion in the silencing element;

FIG. 6 is an isometric view of the sound attenuating

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cartridge shown in FIG. 4, but showing portions thereof broken away;

FIG. 7 is a perspective view of another modified form of our sound attenuating cartridge;

FIG. 8 is a perspective view of another form of the sound attenuating material usable in our cartridge;

FIG. 9 is a perspective view of another form of the sound attenuating material usable in our cartridge;

FIG. 10 is a fragmentary longitudinal section of a conduit having a silencing element employing a cartridge of the type shown in FIG. 9 mounted therein; and

FIG. 11 is a magnified isometric view of a section of the cartridge shown in FIG. 7.

As shown in FIG. 1, our silencing element is mountable in a conduit 10 adapted to be connected at one end to an exhaust manifold 12 by a conventional mounting flange 14, with its opposite end open to the atmosphere. Conveniently, the conduit 10 may have the same outer diameter as the exhaust and tail pipes used in conventional exhaust systems. For example, it may have a diameter of one and three-quarters to two and one-half inches, the diameter of conventional exhaust pipes and tail pipes used on automobiles; but it may have a larger diameter, say as large as four inches, the diameter of conventional exhaust and tail pipes used on trucks, busses, and other large vehicles. While the conduit 10 may be a unitary length, it may also be formed from a plurality of short interconnected lengths of conduit.

In the exhaust system illustrated in FIG. 1, our high frequency silencing element 16 is mounted in the conduit 10 immediately adjacent the rear thereof, and a plurality of low frequency silencing elements 18 are mounted in said conduit upstream from the silencing element 16. The silencing elements 18 are adapted to attenuate the lower range of sound wave frequencies, that is, frequencies below 1500 cycles per second, and to this end, each of the elements 18 may comprise a length of metal-tubing 20 closed at its opposite ends as by end walls 22. A baffle plate 24 is mounted within the tubing 20 intermediate its ends to compartment the tubing 20 into a pair of elongated cavities or resonator volumes 26. Each of the volumes 26 has associated with it a resonator throat-forming tube 28 having one of its ends open to its respective volume 26 and its opposite end open to the gas-flow passage formed by the conduit 10. In this manner, each of the volumes 26 is directly coupled by means of its throat 28 with the gas stream moving through the conduit 10 so that the resonators formed by said throats and volumes will attenuate the noise level of the low frequency sound waves in the exhaust gases. As shown, the elements 18 may be mounted within the conduit 10 on brackets 30, conveniently in the form of sheet-metal stampings which are rigidly secured to said elements and to the inner wall of the conduit 10.

The silencing elements 18 are adapted to attenuate low frequency sound waves below 1500 cycles per second, and because of their throat and volume constructions, may be tuned to preferentially attenuate different frequencies and/or frequency ranges below 1500 cycles per second. The low frequency sound waves to which the elements 18 may be tuned produce sound pressure points along the length of the conduit and inwardly from the ends thereof. Thus, as described in our copending application Serial No. 88,977 filed February 13, 1961, for the elements 18 to be most effective, they should be located inwardly from the ends of the conduit adjacent the pressure points of the frequencies to which they are tuned.

The silencing element 16 is adapted to preferentially attenuate those sound wave frequencies above 1500 cycles per second and is mounted within the conduit 10 immediately adjacent the discharge end thereof in the path of the gas stream moving therethrough. As shown

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in FIG. 2, the silencing element 16 comprises an elongated tube 32 having a plurality of perforations 34 formed therein to render said tube at least 30% open. Said tube has a cross-sectional area in the range of from about 25% to about 75% of the cross-sectional area of the conduit 10 within the axial extent of the element 16 whereby said element will effect the necessary degree of attenuation without requiring it to have such an excessive axial length as to require it to extend into the curved section of the conduit 10, and whereby it will not unduly obstruct gas flow through the conduit and create excessive back pressures therein. As shown, the ends of the tube 32 are closed by a pair of end closures 36, conveniently formed as sheet-metal stampings and removably mounted on said tube by screws 37. As shown, the end closures 36 are shouldered, as at 38, with said shoulders serving as abutments for controlling the insertion of said end closures into said tube. Preferably, the tube 32 with its end closures 36 abuts the inner face of the conduit along one or more lines of contact, and is rigidly connected to the conduit 10 as by welding.

As shown in FIG. 2, the interior of the tube 32 is filled with a cartridge 39 comprising wadding of a porous, fibrous sound attenuating material, such as asbestos fibers, stainless steel wool, glass fibers, or the like, carried in a fine mesh screen 42 of a corrosion resistant material, such as stainless steel, aluminum, or the like, interposed between the sound attenuating material and the tube 32. Like the tube 32, the screen 42 is at least 30% open so that it does not interfere with the acoustic coupling between the sound attenuating material and the gases moving through the conduit 10. However, the fine mesh of the screen 42 renders it more difficult for any of the sound attenuating material to break away from the cartridge and fall through the larger perforations 34 in the tube 32. And conversely, the fine mesh of the screen 42 renders it more difficult for moisture and other foreign matter to come into contact with the sound attenuating material to reduce its porosity and thus its sound attenuating effectiveness.

As will be appreciated, the silencing elements 18 are formed wholly of sheet-metal components which are rigidly secured together, and their destruction by corrosion or the effects of the turbulent gas stream moving through the conduit 10 is negligible. However, in spite of the presence of the screen 42 the sound attenuating material within cartridge 39 may lose its effectiveness as by portions of said sound attenuating material breaking off under the influence of the turbulent blast of the exhaust gases moving through the conduit 10, by moisture or other foreign matter reducing its porosity, or the like. When such a cartridge 39 becomes ineffective, it is merely necessary to remove the screw 37 and the end cap 36 adjacent the discharge end of the tube 32, remove the used cartridge, and replace it with a new cartridge.

A modified form of our cartridge of sound attenuating material is illustrated in FIGS. 4-6, and comprises a fine mesh screen 44 having a mat 46 of a porous, fibrous sound attenuating material disposed over one of its faces. Desirably, the screen 44 is formed from a corrosion resistant material such as stainless steel, aluminum, or the like, and the mat 46 is formed from asbestos fibers, stainless steel wool, glass fibers, or the like. As shown, the screen 44 and the mat 46 are rolled into a generally cylindrically shaped configuration, and after such rolling, they are placed in a wrapper 48, either perforate or imperforate, of combustible material, such as paper, to retain them in their rolled state so that they may be easily inserted into the perforated tube 32' mounted in the conduit 10'. During the normal operation of an internal combustion engine, the exhaust gases emanating from said engine will reach sufficiently high temperatures to ignite the wrapper 48 and thus remove it from the cartridge, with the ash from the burned wrapper being blown

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out the discharge end of the conduit 10'. The complete removal of the wrapper 48 is normally effected within only a few moments after engine start up, and after its removal, said cartridge is in direct acoustic coupling with the interior of the conduit 10' through the perforations 34' and the tubing 32'. Alternatively, a wire may be laced around the spiraled cartridge to hold it compressed for insertion in the tube 32' and, because of its small area, said wire may remain around the cartridge after such insertion.

As shown in FIG. 4, any of the sound attenuating material that is broken off by attrition or other causes will have to pass through at least one layer of the spiraled screen 44 before it will be free to fall through one of the perforations 34'. Conversely, any moisture or other foreign matter will have to pass through the perforations 34' and one or more layers of the spiraled screen 44 before it can become embedded in the mat 46 of sound attenuating material to reduce the porosity thereof and thus reduce its effectiveness as a sound attenuating medium. However, when the cartridge shown in FIGS. 4 and 6 does lose its effectiveness, it may be removed from the tube 32' in the manner of the cartridge 39 shown in FIG. 2 and replaced by a new cartridge.

FIG. 7 illustrates another form of our sound attenuating cartridge. The cartridge shown in FIG. 7 is a self-supporting structure formed of metallic fibers intermingled and rigidly interconnected, such as by welding. Because of the relatively high temperatures of the exhaust gases moving through the conduit, it is desirable to coat some types of metal fibers 49 which may be used in forming such a cartridge with a thin coating of a heat resistant material 50 as shown in FIG. 11 which also serves as a protective coating for said fibers against corrosion. Examples of materials which may be employed as such coatings are alumina, silica, or the like, which are sintered onto the metal fibers after felting. Such coatings serve to further weld the fibers together and thus give the cartridge additional self-supporting rigidity and reduce fiber loss due to attrition. It is to be understood, of course, that the cartridge shown in FIG. 7 is to be used with the silencing element construction shown in FIG. 2 and is replaceable therein in the same manner as the cartridge 39. It is also to be understood that the screen 42 may be interposed between the cartridge shown in FIG. 7 and the tube 32, if desired.

The range of frequencies which a sound attenuating material will attenuate is a function of the density of the material employed, with the higher density materials attenuating a higher range of frequencies than the lower density materials. The sound attenuating material shown in each of the cartridges in FIGS. 2, 6 and 7 has a uniform density. Accordingly, the range of frequencies which said cartridges will preferentially attenuate is limited. To increase the range of frequencies attenuated by said cartridges, the sound attenuating material employed therein may take either of the forms shown in FIGS. 8 and 9.

The sound attenuating material shown in FIG. 8 comprises a dense central core 52 of sound attenuating material disposed within an annular layer 54 of material having a substantially lower density and thus adapted to attenuate a lower range of frequencies than the core 52. In addition to effecting an attenuation of a lower range of frequencies than the core 52, the layer 54, being less dense than said core, will have less tendency for its fibers to be broken and will thus tend to retain any broken core fibers within the cartridge.

As will be understood, the multiple layer construction of FIG. 8 may be formed for use in the cartridges in FIGS. 2 and 7 simply by wrapping the more dense core 52 within the outer layer 54 and, in the case of the cartridge in FIG. 7, sintering the fibers of the core 52 and layer 54 together. To form such a multiple layer construction in the cartridge in FIG. 6, a layer of less

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dense sound attenuating material is interposed between the screen 44 and a layer of a more dense sound attenuating material, and the several components are rolled into a spiraled cylindrical configuration.

The embodiment shown in FIG. 9 also shows a construction employing sound attenuating material having sections of different densities. In such embodiment, sections 56 of a less dense material are alternately disposed between sections 58 of a more dense material. To employ such a construction in the cartridges in FIGS. 2 and 7, the sections 56 and 58 are simply disposed in alignment and, in the case of FIG. 2, the screen 42 is wrapped therearound and, in the case of FIG. 7, the fibers in each section are sintered to each other and to the fibers in the next adjacent section. To employ such construction in the cartridge in FIG. 6, strips of the sections 56 and 58 are alternately placed on the screen 44, and said screen and strips are then rolled into a spiraled cylindrical configuration.

The embodiment shown in FIG. 9, like the embodiment in FIG. 8, makes it possible to retain any broken fibers from the more dense sections 58 within cartridge. As shown in FIG. 10, the cartridge of FIG. 9 may be mounted in a tube 60 carried within a conduit 61 with said tube being provided with perforations 62 only in positions such that they will be aligned with the less dense sections 56. Thus, the more dense sections 58 will be disposed within the imperforate wall portions of the tube, and any fibers broken therefrom will thus be retained in the cartridge. The less dense sections 56 in such an arrangement acoustically couple the sections 58 to the gas stream.

In order to achieve the maximum utilization of space, all of the different forms of our replaceable cartridges of sound attenuating material are of a size such that they substantially completely fill the interior of the perforated tube in which they are carried.

We claim:

1. A silencing element for an exhaust gas conduit, comprising an elongated perforated tube rigidly mounted in said conduit adjacent the discharge end thereof, said tube having a cross-sectional area of from about 25% to about 75% of the cross-sectional area of said conduit, said tube having end closures at its opposite ends with the end closure adjacent the discharge end of said conduit being removably mounted on said tube, and a cartridge of porous, fibrous sound attenuating material insertable into said tube upon removal of said end closure adjacent said discharge end and retained therein by said end closure.

2. A silencing element as set forth in claim 1 in which said tube abuts the inner face of said conduit along at least one axially extending line of contact.

3. A silencing element for an exhaust gas conduit, comprising an elongated perforated tube rigidly mounted in said conduit adjacent the discharge end thereof with at least a substantial portion of its wall area spaced from

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said conduit, said tube having end closures at its opposite ends with the end closure adjacent the discharge end of said conduit being removably mounted on said tube, and a cartridge of porous, fibrous sound attenuating material insertable into said tube upon removal of said end closure adjacent said discharge end and retained therein by said end closure.

4. The invention as set forth in claim 3 with the addition that said sound attenuating material comprises an inner core of said sound attenuating material carried within an outer layer of said sound attenuating material, the material forming said inner core having a higher density than the material forming said outer layer.

5. The invention as set forth in claim 3 with the addition that said sound attenuating material is disposed in aligned sections having a plurality of densities.

6. The invention as set forth in claim 3 with the addition that said sound attenuating material is disposed in aligned sections of higher and lower densities, and said tube is perforated only within the extent of the lower density sections.

7. A silencing element as set forth in claim 3 with the addition that the outer surface of said cartridge comprises a screen of a corrosion resistant material, said screen having a finer mesh than said perforated tube.

8. A silencing element as set forth in claim 3 with the addition that said cartridge is a self-supporting structure of rigidly connected, interwoven, corrosion resistant metal fibers, said structure substantially completely filling the interior of said tube.

9. A silencing element as set forth in claim 8 with the addition that said fibers have a thin coating of a heat-stable ceramic-type material.

10. A silencing element as set forth in claim 3 with the addition that said cartridge comprises a screen of corrosion resistant material having a mat of said sound attenuating material disposed over one of its faces, said screen and mat having a spiraled cylindrical configuration.

11. A silencing element as set forth in claim 10 with the addition that a wrapper of readily combustible material is disposed over said cartridge.

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