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3,276,540

APPARATUS FOR ATTENUATING SOUND WAVES IN GAS STREAMS
AND METHOD OF PRODUCING SAME

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2 Sheets-Sheet 1

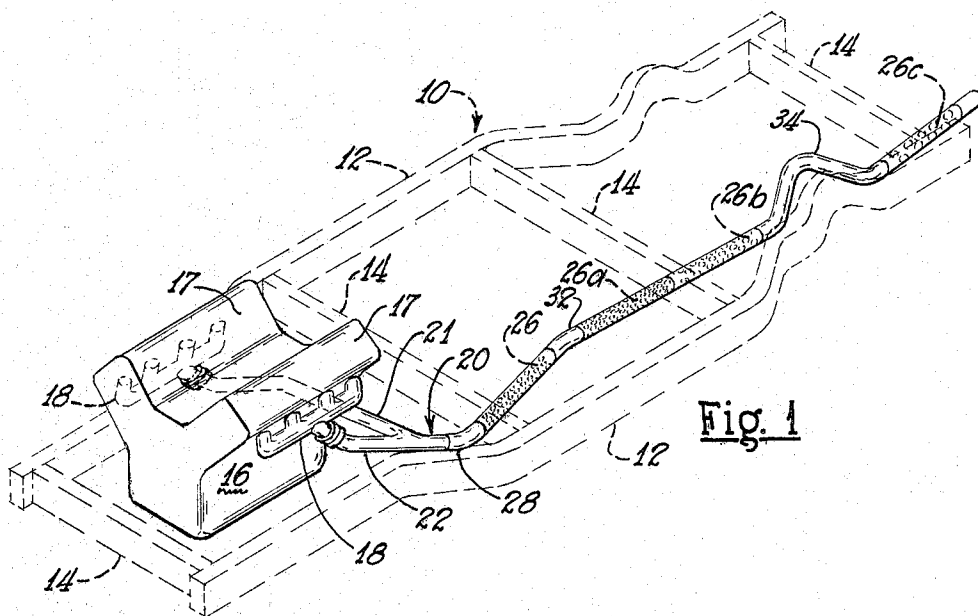


Fig. 1

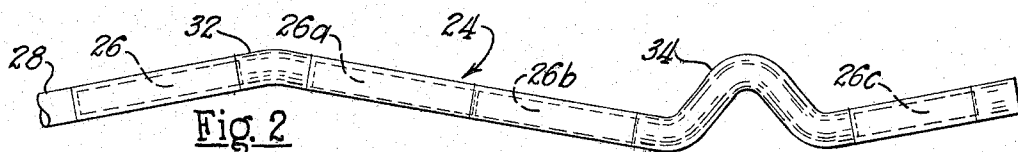


Fig. 2

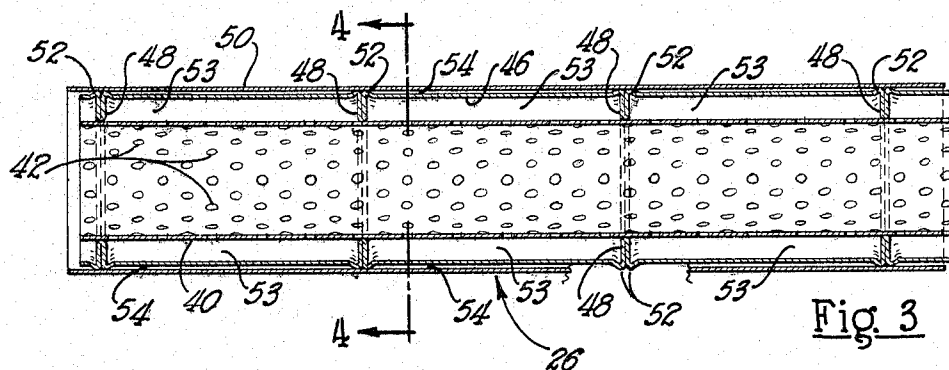


Fig. 3

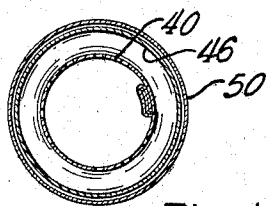


Fig. 4

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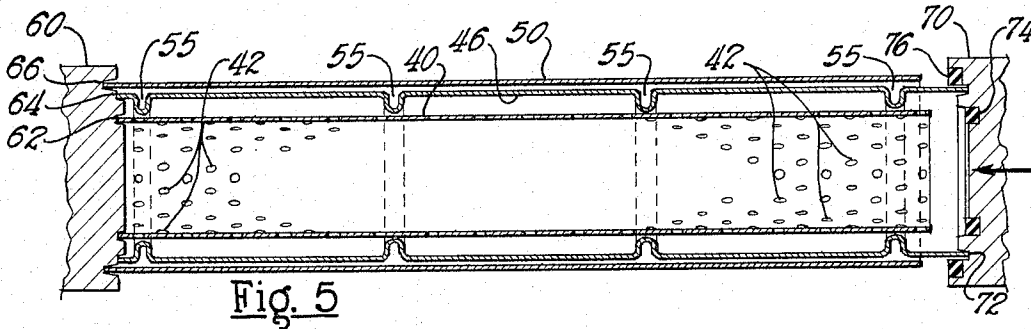
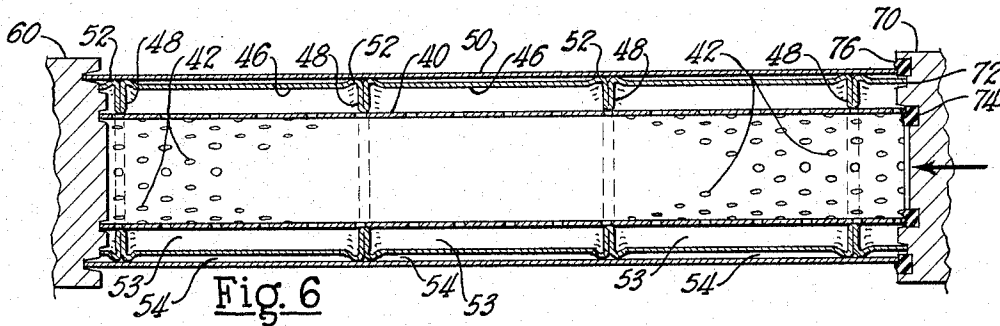
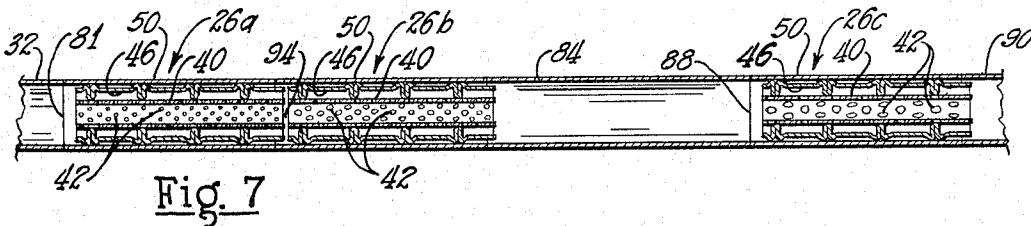
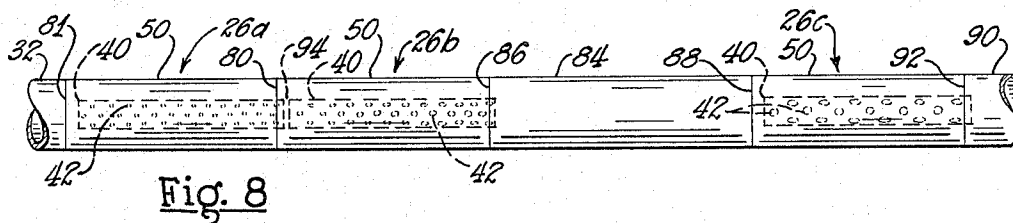
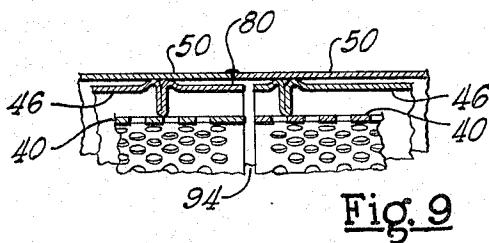
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2 Sheets-Sheet 2



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APPARATUS FOR ATTENUATING SOUND WAVES IN GAS STREAMS AND METHOD OF PRODUCING SAME

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This invention relates to the attenuation of sound waves in gas streams and particularly to apparatus for attenuating sound waves in exhaust gas streams from internal combustion engines and to a method of producing the apparatus.

It has been conventional practice in connection with automotive vehicles powered by internal combustion engines to convey the exhaust gases through a sound attenuating muffler or silencer of substantial size to attenuate sound waves in the exhaust gas streams. A recent trend in automotive design is to lower the vehicles and such design necessitates additional struts and stress resisting frame members and such frame members render difficult the installation and use of conventional muffler constructions.

Recent developments have been made in the use of an exhaust conduit construction embodying a plurality of connected sound attenuating units wherein the outer shells or members of the attenuating units are connected together in end-to-end relation to form a combined exhaust pipe and sound attenuating means.

It is found that in the use of constructions of this character considerable so-called "shell noise" is developed by reason of the comparatively thin single outer shells of the sound attenuating constructions connected to provide the exhaust gas conduit. Constructions of such character are desirable in that they provide for a substantially unobstructed gas passage means with a plurality of sound attenuating constructions disposed in close relation or spaced in end-to-end relation, and by reason of the length of the assembly of attenuating units, objectionable sound waves in the gas stream are attenuated but the single layer outer shells are readily responsive to sound vibrations causing "shell noise."

The present invention embraces an arrangement providing an exhaust pipe or conduit construction or tuned exhaust pipe assembly comprising a plurality of sound attenuating units or devices, each including an outer shell, tube or second layer of sheet metal and the outer layers connected together or connected by tubular couplings or pipes whereby a continuous exhaust gas conveying means or exhaust pipe is provided embodying double walls at the regions of the sound attenuating units whereby "shell noise" is substantially reduced or eliminated.

Another object of the invention resides in a method of forming a sound attenuating unit or construction having a central gas passage means, a plurality of sound attenuating chambers adjacent and surrounding the gas passage means and an outer wall or layer embracing the sound attenuating means wherein an intermediate shell of the sound attenuating means is distorted by lengthwise pressure during processing into close or snug engagement with the gas passage means and the outer shell or layer whereby the components are held in assembled relation by the distorted regions or portions of the intermediate shell providing annular spaces between the intermediate and outer shells to reduce "shell noise."

Another object of the invention is the provision of an exhaust gas conveying means for use with an internal combustion engine comprising two or more sound attenuating units, each embodying double layer casings or shells in slightly spaced relation to promote the reduction or

elimination of "shell noise" and wherein the outer layers or shells of the said units are coupled together directly or coupled by intermediate tubular members to provide a combined continuous exhaust imperforate gas passage tube and sound attenuating means arranged to be connected with the exhaust manifold of the engine and to extend to a rearmost region of the vehicle.

Another object of the invention resides in a method of fabricating a dual shell casing of a sound attenuating construction wherein one of the shells is contracted in a lengthwise direction to effect a transverse distortion of lengthwise spaced regions thereof into snug engagement with the outer shell to secure the shells in assembled relation and provide a plurality of closed annular chambers between the shells.

Further objects and advantages are within the scope of this invention such as relate to the arrangement, operation and function of the related elements of the structure, to various details of construction and to combinations of parts, elements per se, and to economies of manufacture and numerous other features as will be apparent from a consideration of the specification and drawing of a form of the invention, which may be preferred, in which:

FIGURE 1 is a phantom or a schematic view of the frame or chassis construction of an automotive vehicle and internal combustion engine illustrating a form of tuned exhaust pipe assembly or sound attenuating system of the invention;

FIGURE 2 is an elevational view of the sound attenuating or tuned exhaust pipe illustrating one arrangement of sound attenuating units in the exhaust system for use with an internal combustion engine;

FIGURE 3 is a longitudinal sectional view illustrating one of the sound attenuating units of the exhaust system;

FIGURE 4 is a transverse sectional view taken substantially on the line 4—4 of FIGURE 3;

FIGURE 5 is a longitudinal sectional view illustrating a step in the method of forming one of the sound attenuating units;

FIGURE 6 is a sectional view similar to FIGURE 5 illustrating a further step in the method of forming the sound attenuating unit;

FIGURE 7 is a longitudinal sectional view showing a plurality of attenuating units in connected relation forming a combined gas passage and sound attenuating construction;

FIGURE 8 is an elevational view of the construction shown in FIGURE 7, and

FIGURE 9 is a transverse sectional view illustrating the method of joining adjacent attenuating units.

The longitudinally aligned assembly of sound attenuating units and coupling tubes in end-to-end relation, provides a combined exhaust pipe and sound attenuating construction or tuned exhaust pipe having particular utility as an exhaust system for internal combustion engines in automotive vehicle constructions, the arrangement providing an effective instrumentality for attenuation of sound waves of varying lengths entrained in the exhaust gas stream and for reducing "shell noise," the tubular assembly being configurated to avoid interference with other structural components of the vehicle.

Referring to the drawings in detail and initially to FIGURE 1, there is illustrated in phantom or schematic form, a vehicle frame or chassis 10 embodying longitudinally extending side frame members 12 and transversely disposed struts or reinforcing members 14. The frontal region of the frame 10 supports an internal combustion engine 16 of conventional V-type construction having two banks 17 of cylinders equipped with exhaust manifolds 18, an exhaust pipe or gas conveying tube 20 is fashioned with branches 21 and 22 connected with the respective manifolds 18 of the engine.

In the arrangement shown in FIGURE 1, the exhaust gas streams from both banks of cylinders 17 are converged into a single tubular means which is connected with the tuned exhaust pipe system of the invention, the latter being preferably of a character for conveying the exhaust gases for discharge at the rear of the vehicle. While FIGURE 1 is illustrative of an arrangement employing a single tubular exhaust conveying system for the exhaust from both banks of cylinders, it is to be understood that a separate exhaust conveying and sound attenuating means or system may be employed for the exhaust stream from each bank of cylinders.

The exhaust conveying and sound attenuating arrangement of the invention comprises a plurality of gas-conveying and sound attenuating units, each contained within an outer shell or enclosure and the outer shells or enclosures welded or otherwise coupled together in end-to-end relation or with coupling tubes to form a continuous exhaust gas conveying tube or tubular construction.

As shown in FIGURES 1 and 2, the composite tubular construction 24 comprises attenuating units 26, 26a, 26b and 26c, the unit 26 being joined by a coupling tube 28 with the exhaust pipe 20, the units 26 and 26a being coupled together by a tubular coupling 32, units 26a and 26b directly joined together, and the units 26b and 26c coupled by a tubular component 34 of a configuration to provide clearance or jounce space for an axle of the vehicle. The units 26 through 26c are of substantially the same construction although they may be fashioned of varying lengths and may be spaced lengthwise other than the arrangement illustrated in FIGURES 1 and 2 in order to attenuate a particular range of sound waves depending upon the degree or efficiency of sound attenuation desired.

One of the attenuating units 26 is illustrated in FIGURES 3 and 4, and steps in the method of assembling the components of the attenuating units are illustrated in FIGURES 5 and 6. With particular reference to FIGURE 3 each attenuating unit or construction is inclusive of a central tubular member 40 which provides a gas passage means or tube, the wall of the tube 40 being provided with a comparatively large number of small openings 42. Surrounding the gas passage tube 40 and spaced therefrom is a second tubular member or shell 46 which is preferably of circular cross section and concentric with the tube 40 as shown in FIGURE 4.

The shell 46 is distorted or configured at lengthwise spaced regions during forming operations providing transverse partitions 48 which engage the peripheral surface of the gas passage tube 40 to secure the tube 40 and shell 46 in assembled relation. In the attenuating unit of the invention, an outer shell or tube 50 is telescoped over the adjacent shell 46 and is secured in fixed relation with the shell 46 by raised ridges 52 formed of the metal of the shell 46 during distortion of the spaced regions of the shell to form the partitions 48.

Each of the attenuating units, as shown in FIGURE 3, comprises an outer tubular layer or shell 50 and an adjacent inner shell 46, the shell 46 being of slightly lesser diameter than the shell 50 providing annular spaces or chambers 54 of a length equal to the distance between adjacent ridges 52, the annular chambers 54 providing closed air spaces functioning as cushioning means for reducing "shell noise" or noises caused by vibration of the shell 46 set up by sound waves of the moving exhaust gases.

The friction set up in the method of assembly between the distorted portions forming the partitions 48 and the gas passage tube 40 and between the outwardly distorted ridges 52 and the outer tube or shell 50 securely retains or holds these components of each attenuating unit in proper relation without extraneous fastening means. The annular spaces 53 between the gas passage tube 40 and the shell 46 and defined lengthwise by the partitions 48 provide sound attenuating chambers acoustically coupled

with the interior of the gas passage tube 40 by the openings 42.

FIGURES 5 and 6 illustrate steps in the method of assembling the gas passage tube 40, the shell or tubular member 46 and the outer shell or closure 50. The shell 46 is initially of cylindrical tubular configuration, and in a preforming operation at spaced regions along the tube, the metal is spun or distorted inwardly to form the peripheral recesses or grooves 55. The inner diameter of each of the inwardly extending ridges provided by a recess 55 is slightly greater than the diameter of the outer surface of the gas passage tube 40, the latter being telescoped interiorly of the shell 46 in the position shown in FIGURE 5, and the outer tube or shell 50 telescoped over the shell 46.

Disposed at one end of this assembly is a base block or bolster 60 fashioned with a first circular groove 62 to accommodate the end of the gas passage tube 40, a circular ledge 64 against which abuts the end of the shell 46, and a second circular groove 66 which receives an end of the outer shell or tube 50. Disposed at the opposite end of the assembly is a movable ram 70 of a conventional press (not shown) fashioned with a circular groove 72 which receives the opposite end of the shell 46 during closing or operative movement of the press ram.

As will be apparent from FIGURE 5, the shell 46, prior to the distortion operation to form the partitions 48 shown in FIGURES 3 and 6, extends a substantial distance beyond the adjacent ends of the gas passage tube 40 and the tube or outer shell 50.

The press ram 70 is fashioned with a circular recess accommodating an annular member 74 of rubber or other non-metallic material which is aligned with the gas passage tube 40. The ram 70 is provided with a ledge forming a seat for a second annular member 76 of rubber or other nonmetallic material aligned with the outer shell or closure 50.

With the components 40, 46 and 50 predisposed in the relative positions shown in FIGURE 5, the ram 70 is moved toward the components to the position shown in FIGURE 6. During movement of the ram to this position, the ram exerts lengthwise crushing or compressive forces against the shell 46, lengthwise thereof, which forces distort the regions of the shell defining the grooves 55 to bend or distort the metal to form the double layer partitions 48. By reason of the crushing stresses exerted on the tube 46, outwardly extending circular beads or ridges 52 are formed which frictionally and snugly engage the outer shell or closure 50 in the manner shown in FIGURES 6 and 9.

Thus a complete attenuating unit with the outer shell is formed by the method step shown in FIGURE 6. The annular members 76 and 74 carried by the ram 70 provide resilient cushions to prevent damage to or distortion of the gas passage tube and the outer shell or tube 50 during the step of distorting portions of the shell 46 in assembling the components.

As particularly shown in FIGURE 3, the left-hand end of the outer shell or tube 50 extends beyond the adjacent ends of the shell 46 and gas passage tube 40 while at the other end of the assembly, the shell 46 and the gas passage tube 40 extend beyond the adjacent end of the outer shell 50. FIGURE 9 illustrates the relative positions of adjacent attenuating units with the outer shells 50 aligned and welded together to form a continuous tubular construction.

In assembly, the ends of outer shells 50 are abutted and welded as at 80 throughout the circumference of the butting regions of the walls to form a continuous impervious tube. It will be noted from FIGURE 9 that the ends of adjacent gas passage tubes 40 and adjacent ends of the inner shells 46 are respectively aligned but are slightly spaced as at 94 to facilitate the welding 80 without interference between adjacent ends of the members 40 and 46.

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FIGURES 7 and 8 illustrate a modified assembly of several sound attenuating units with the outer shells joined to provide a single exhaust pipe or gas passage tube. As shown in FIGURES 7 and 8, two attenuating units 26a and 26b of substantially identical construction, are disposed in abutting relation and the outer shells 50 welded together at the weld line 80. The forward end of the unit 26a may be welded as at 81 to a coupling tube such as the tube 32 shown in FIGURE 1.

A third unit 26c of the arrangement shown in FIGURES 7 and 8 is spaced from the other units by a length of tubing 84 of the same diameter as the outer shells 50, the ends of the tube 84 being welded to the adjacent ends of the attenuating units as at 86 and 88. The third attenuating unit may be welded to a tailpipe member 90 as at the weld line 92. The outer shells 50 of the attenuating units with the connecting tube 84 provide a continuous imperforate exhaust gas passage tube which may be of a shape similar to that shown in FIGURE 1 for conveying exhaust gases from the engine exhaust manifold for discharge into the air through the tailpipe 90.

It is to be understood that the intermediate or coupling tube 84 may be bent to a desired shape such as the tube 34 shown in FIGURE 2 to provide clearance space for a component of the vehicle frame construction.

The assemblage of sound attenuating units having their outer shells welded together or joined by coupling tubes in the manner described provides a comparatively long imperforate tubular means or pipe for conveying exhaust gases and enclosing the attenuating units for attenuating sound waves over a broad range of valve lengths to attain improved sound attenuation and reduce "shell noise."

Through this arrangement sound waves of short length and high pitch are readily attenuated as well as longer waves of low pitch by reason of the substantial distance traversed by the exhaust gases in moving through successive sound attenuating units.

It is to be understood that the relative lengthwise arrangement of the sound attenuating units may be varied by interposing a tubular coupling member, such as members 32, 34 or 84 between each pair of sound attenuating units, and such tubular members or couplings may be of varying lengths to secure desired attenuation of sound waves.

It is apparent that, within the scope of the invention, modifications and different arrangements may be made other than as herein disclosed, and the present disclosure is illustrative merely, the invention comprehending all variations thereof.

I claim:

1. Apparatus for attenuating sound waves in a gas stream, in combination, a tubular member providing a gas passage means having a perforated wall region, an outer imperforate walled tube of larger diameter surrounding said tubular member, an intermediate tube disposed between the perforated tubular member and the outer imperforate walled tube and spaced from both the inner tubular member and the outer tube, the intermediate tube having lengthwise spaced circumferential portions engaging the perforated tubular member and the outer tube for securing the tubes and tubular member in assembled relation, said portions engaging the inner tubular member defining lengthwise-arranged annular sound attenuating chambers acoustically coupled with the interior of the tubular member through the perforations in the wall of the gas passage tube.

2. Apparatus of the character disclosed including, in combination, an inner tubular shell, an outer tubular shell of larger diameter surrounding said inner tubular shell, an intermediate tubular shell disposed between the inner and outer shells and spaced therefrom, said intermediate shell having lengthwise spaced integral circumferential portions engaging the inner shell and the outer shell retaining the shells in assembled relation and providing annular chambers between the inner and intermediate shells and between the intermediate and outer shells.

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3. Apparatus for attenuating sound waves in a gas stream, in combination, a tubular member providing a gas passage means having a perforated wall region, an outer imperforate walled tube of larger diameter surrounding said tubular member, an intermediate tube disposed concentrically between the tubular member and the outer imperforate walled tube and spaced from both the inner tubular member and outer tube, the intermediate tube having lengthwise spaced circumferential portions engaging the inner tubular member and the outer tube for securing the tubes in assembled relation, said portions engaging the inner tubular member defining lengthwise-arranged annular sound attenuating chambers acoustically coupled with the interior of the tubular member through the perforations in the wall of the tubular member, the portions of the intermediate tube in engagement with the outer tube defining annular air chambers between the intermediate tube and the outer tube for reducing shell noise.

4. Apparatus for attenuating sound waves in a gas stream, in combination, an inner tubular shell providing a gas passage means having a perforated wall region, an outer tubular shell of larger diameter surrounding said inner shell, an intermediate tubular shell disposed between the inner shell and the outer shell and spaced from both the inner and outer shells, the intermediate shell having lengthwise spaced integral circumferential portions extending inwardly in engagement with the inner shell and outwardly in engagement with the outer shell securing the shells in assembled relation, said inwardly extending portions defining lengthwise-arranged annular sound attenuating chambers acoustically coupled with the interior of the inner shell through the perforations in the wall region thereof, the outwardly extending portions of the intermediate shell in engagement with the outer shell defining annular air chambers surrounding the intermediate shell.

5. Apparatus for attenuating sound waves in a gas stream, in combination, a gas passage tube having a perforated wall, an outer imperforate walled shell of larger diameter surrounding said gas passage tube, an intermediate shell disposed between and concentric with the gas passage tube and the outer shell, said intermediate shell being spaced from both the gas passage tube and the outer shell, the intermediate shell having integral circumferential portions extending inwardly in engagement with the gas passage tube and outwardly in engagement with the outer shell for securing the gas passage tube and shells in assembled relation, said inwardly extending portions providing partitions defining annular sound attenuating chambers acoustically coupled with the interior of the gas passage tube through the perforations in the wall of the gas passage tube, the outwardly extending portions of the intermediate shell in engagement with the outer shell defining closed annular air chambers between the intermediate shell and the outer shell.

6. A system for attenuating sound waves in an exhaust gas stream from an internal combustion engine, a plurality of sound attenuating constructions, each of said sound attenuating constructions including a perforated gas passage tube, an imperforate walled tube spaced laterally and surrounding the gas passage tube, said imperforate walled tube having spaced regions extending inwardly and engaging the gas passage tube forming a plurality of lengthwise arranged sound attenuating chambers surrounding the gas passage tube, an imperforate tubular outer shell surrounding each of said sound attenuating constructions, the outer shells surrounding the sound attenuating constructions being connected to provide a continuous imperforate exhaust gas conveying channel.

7. A system for attenuating sound waves in exhaust gas streams including, in combination, a plurality of sound wave attenuating constructions arranged in lengthwise relation, each of said constructions including a perforated gas passage tube and a tubular shell surrounding and spaced from the gas passage tube, said shell having length-

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wise spaced integral portions engaging the gas passage tube forming a plurality of sound attenuating chambers surrounding the gas passage tube and acoustically coupled therewith through the perforations in the gas passage tube, an outer imperforate tube surrounding each of said sound attenuating constructions, said shell having raised circumferential portions engaging the outer tube and forming therewith a plurality of closed annularly shaped air chambers between the shell and the outer tube, the outer tubes surrounding the sound attenuating constructions being connected together to form an imperforate exhaust gas conveying channel.

8. A system for attenuating sound waves in exhaust gas streams including, in combination, a plurality of sound wave attenuating units arranged in lengthwise relation, each of said units including a perforated gas passage tube and a tubular shell surrounding and spaced laterally from the gas passage tube, said shell having spaced integral portions engaging the gas passage tube forming a plurality of sound attenuating chambers surrounding the gas passage tube and acoustically coupled therewith

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through the perforations in the wall of the gas passage tube, an outer imperforate walled tube surrounding each of said attenuating units, said tubular shell having raised circular portions engaging the outer tube and forming therewith a plurality of closed annularly shaped air chambers between the tubular shell and the outer tube, a tubular member arranged between adjacent attenuating units, said tubular member being welded to the outer tubes surrounding adjacent attenuating units providing an imperforate exhaust gas conveying channel.

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