Jan. 8, 1963 F. E. DEREMER 3,072,214

GAS BLENDING AND SOUND-ATTENUATING SYSTEM AND APPARATUS

Filed Feb. 14, 1958 3 Sheets-Sheet 1

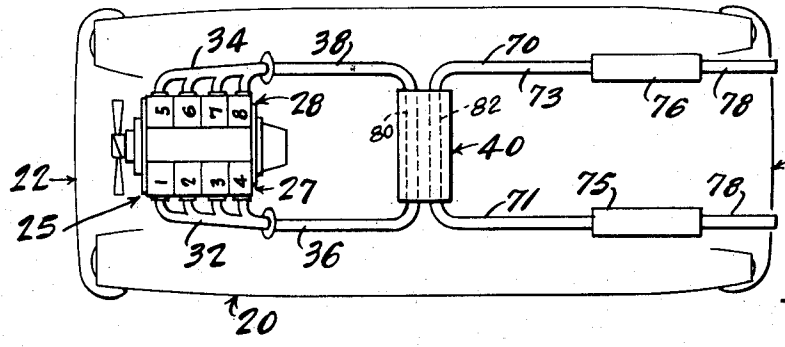


FIG-1-

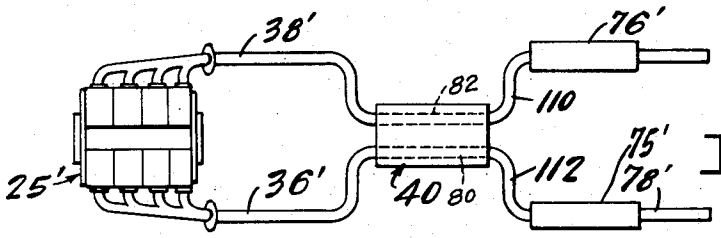


FIG-2-

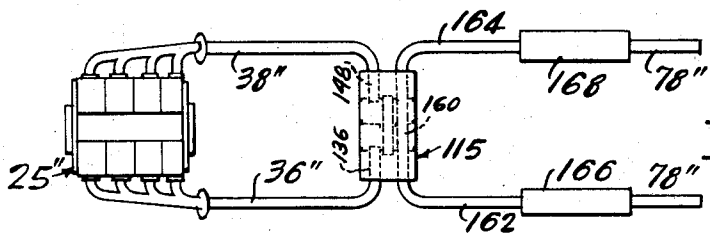


FIG-3-

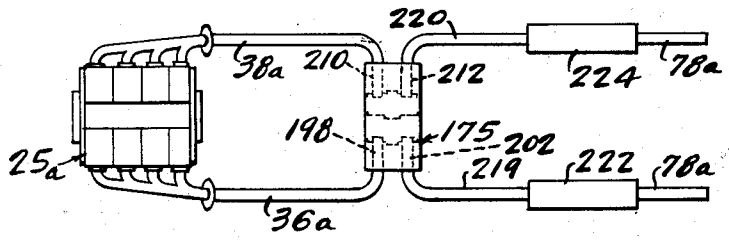


FIG-4-

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GAS BLENDING AND SOUND-ATTENUATING SYSTEM AND APPARATUS

Filed Feb. 14, 1958 3 Sheets-Sheet 2

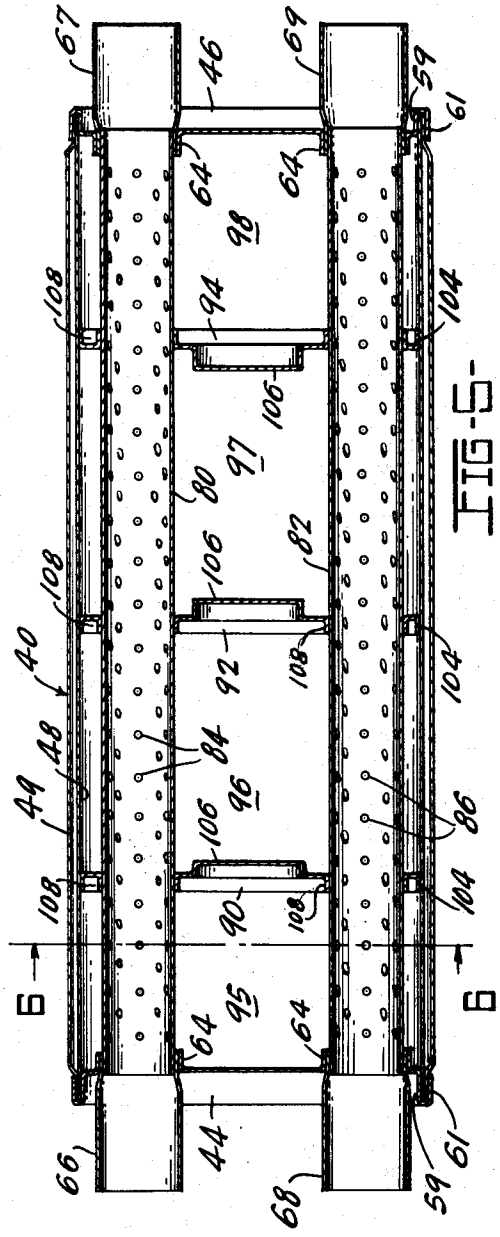


FIG-5-

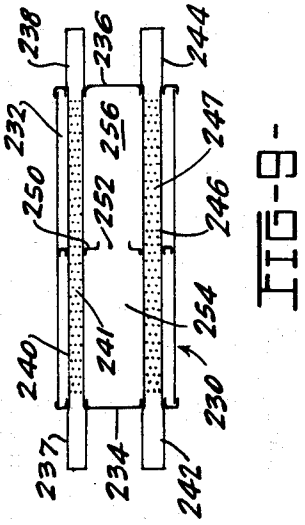


FIG-9-

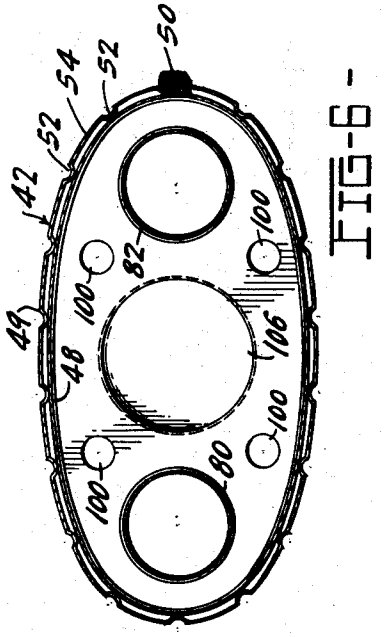


FIG-6-

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GAS BLENDING AND SOUND-ATTENUATING SYSTEM AND APPARATUS

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FIG-7-

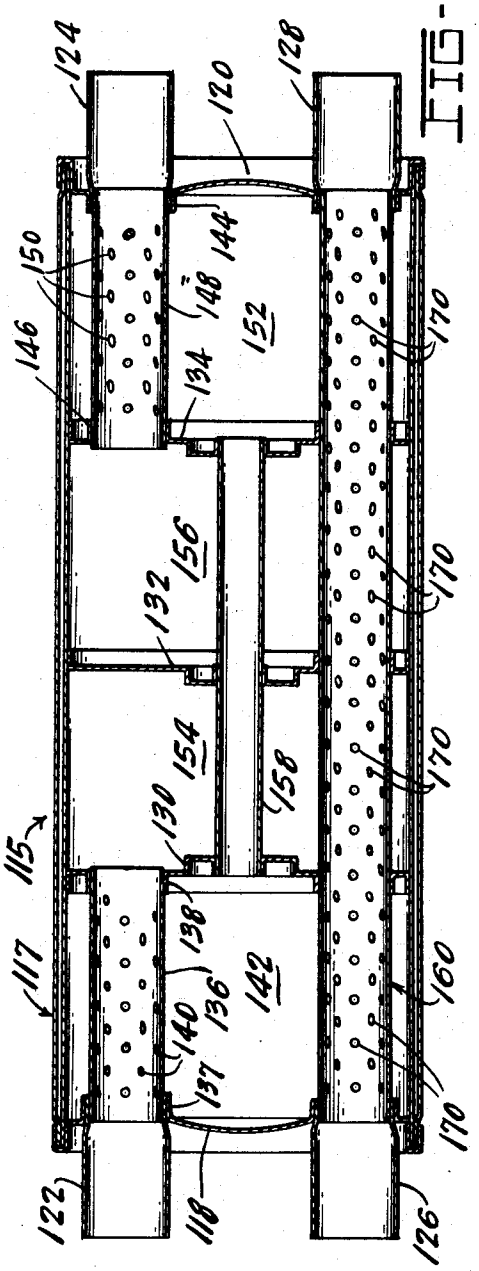
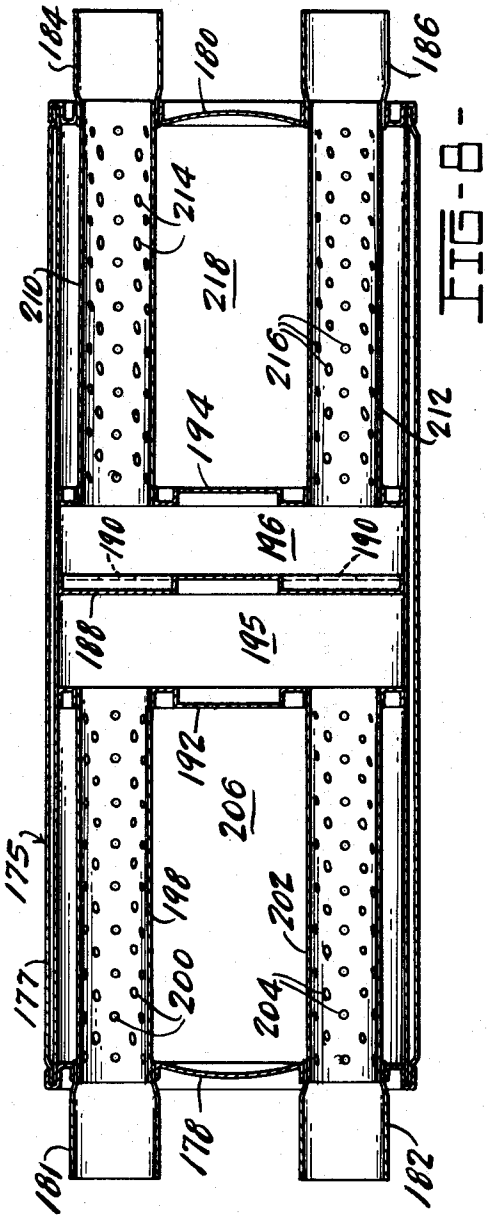


FIG-8-



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3,072,214

GAS BLENDING AND SOUND-ATTENUATING SYSTEM AND APPARATUS

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Filed Feb. 14, 1958, Ser. No. 715,444
9 Claims. (Cl. 181—48)

This invention relates to a sound-attenuating and gas blending system and apparatus for blending two or more gas streams in a chamber or zone and attenuating sound waves entrained in the gas streams, the invention pertaining more especially to a system embodying a gas blending and sound-attenuating chamber for use with multiple exhaust gas streams from an internal combustion engine of the character employed in automobile vehicles.

In the development and manufacture of internal combustion engines or prime movers for use in powering automotive vehicles, more extensive use is being made of eight cylinder engines of a type embodying two parallel banks of cylinders with four cylinders in each bank, an individual exhaust manifold utilized with each bank of cylinders and one or more sound-atttenuating means or mufflers embodied in the exhaust duct arrangement for the gas stream issuing from each manifold.

A factor influencing vehicle manufacturers to utilize individual exhaust gas attenuating systems for each exhaust gas stream is the substantial increase in the horsepower of the engines which results in an increased volume of exhaust gases to be disposed of in each exhaust duct arrangement and to attenuate sound waves in such systems without appreciably increasing back pressure in the exhaust ducts. In many such installations, a sound-attenuating device or muffler for each of the gas streams suitable or adaptable for attenuating sound waves in the objectionable sound wave range has not been satisfactory by reason of the trend in lowering the frame construction of the vehicle to such an extent that the reinforcing cross members of the frame reduce the available space to accommodate a sound-attenuating muffler of a length adequate to attenuate sound waves in an exhaust gas stream. Hence a dual exhaust gas duct arrangement for dual exhaust gas streams of an engine may embody a sound-attenuating muffler for each stream of a length that may be accommodated between the frame cross members supplemented by a secondary sound-attenuating means or resonator chamber spaced therefrom in order to attenuate sound waves entrained in the high velocity exhaust gas streams.

Another factor that has a direct influence upon the attenuation of sound waves in dual exhaust streams delivered from the two banks of cylinders in an eight cylinder engine is the firing order of the cylinders. In the design of multi-cylinder engines embodying two parallel banks of cylinders where all of the pistons are connected to a single crankshaft, the firing or ignition of the fuel and air charges in the cylinders in each bank do not occur at regular intervals.

In a conventional eight cylinder engine having two banks of four cylinders each, successive firing of two cylinders occurs in each bank and the remaining cylinders of the banks are alternately fired. Thus during a complete cycle of ignition or firing of the eight cylinders in an engine of this character, two successive exhaust impulses occur in each exhaust manifold of each of the banks of cylinders. The irregularity of the pressure impulses in each exhaust manifold sets up irregular or nonrhythmic pulsations of the gas streams which cause a distinct audible throbbing in each exhaust gas duct arrangement. Efforts to eradicate this audible throbbing have heretofore been unsuccessful.

The present invention embraces a system and apparatus satisfactorily attenuating sound waves entrained in multiple gas streams subjected to irregular pressure impulses.

An object of the present invention is the provision of a system or method of blending streams of gas in an intermediate zone or chamber and attenuating sound waves in the zone or chamber and thereafter directing the blended gases through one or more sound-attenuating means whereby substantially all of the objectionable sound waves are damped out or attenuated prior to the discharge of the gases from the sound-attenuating means.

An object of the invention is the provision of a method or system of blending gases of dual exhaust gas streams from an internal combustion engine wherein pressure impulses in the streams occur at nonuniform intervals whereby the pressures of the impulses are substantially neutralized or equalized and sound waves attenuated in the blending zone and the blended gases delivered to one or more sound-attenuating means wherein further sound-attenuation ensues and audible sounds otherwise arising from the nonuniform impulses are substantially eradicated or their audibility rendered unobjectionable.

Another object of the invention resides in a system and apparatus for blending dual exhaust gas streams from banks of cylinders of a multi-cylinder engine wherein pressure impulses in the exhaust gas streams may be unequal in magnitude and of irregular occurrence whereby objectionable sound waves entrained in the gas streams are substantially attenuated.

Another object of the invention is the provision of an intermediate or transition chamber in which two or more gas streams are blended to smooth out or minimize pressure impulses in the streams and in which sound waves are attenuated.

Another object of the invention is the provision of a sound-attenuating chamber adapted to receive dual exhaust gas streams wherein the gases of the streams are directed toward each other and blended together whereby sound waves entrained in the streams are attenuated.

Another object of the invention is the provision of a resonator chamber adapted to receive and accommodate two streams of exhaust gases from an internal combustion engine, the chamber embodying gas passage means facilitating transverse or cross flow of gases within the chamber whereby one or more streams of blended gases are delivered from the resonator chamber.

Still a further object of the invention is the provision of an intermediate chamber for use in an exhaust gas system of an eight cylinder engine from which dual exhaust streams are delivered into the chamber, the chamber having gas passage means in transverse spaced relation within the chamber, the walls of the gas passage means being formed with openings or open areas forming acoustic couplings with compartments within the chamber for attenuating sound waves and for facilitating transverse flow and blending of exhaust gases whereby the gases flow through the chamber into outlet or discharge means with a minimum of back pressure.

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 schematic plan view of an exhaust system for a multi-cylinder engine embodying dual banks of cylinders arranged in parallel relation with a separate exhaust manifold for each bank of cylinders;

FIGURE 2 is a view similar to FIGURE 1 showing a

modified position of a gas blending chamber forming a component of the system;

FIGURE 3 is a view similar to FIGURE 2 illustrating a modified form of gas blending chamber of the invention;

FIGURE 4 is a view similar to FIGURE 3 illustrating another form of gas blending chamber of the invention;

FIGURE 5 is a longitudinal sectional view of one form of gas blending and sound-attenuator chamber of the invention;

FIGURE 6 is a transverse sectional view taken substantially on the line 6—6 of FIGURE 5;

FIGURE 7 is a longitudinal sectional view showing another form of gas blender and sound-attenuator of the invention;

FIGURE 8 is a longitudinal sectional view showing another form of gas blending and sound-attenuating means, and

FIGURE 9 is a schematic view illustrating another form of gas blending chamber and sound-attenuator.

While the invention has particular utility in blending gases from dual exhaust gas streams from an internal combustion engine utilized as a prime mover or power unit for an automotive vehicle, it is to be understood that the system and apparatus of the invention may be utilized wherever the same may be found to have utility.

The invention has particular utility with the exhaust system of a multi-cylinder engine of the type embodying parallel banks of cylinders such as an eight cylinder engine with four cylinders in each bank. A separate exhaust manifold is provided to accommodate exhaust gases from each bank of cylinders. In eight cylinder engines comprising two banks of cylinders wherein the pistons are connected with a single crankshaft, the arrangement does not permit of successive firing of cylinders alternately from each bank throughout a complete firing cycle of the eight cylinders.

During a complete cycle of ignition or firing of all eight cylinders of the engine, there are two periods wherein two cylinders of one bank are fired in succession and two cylinders of the opposite bank fired in succession, the others being alternately fired from opposite banks. This condition results in two exhaust impulses in close succession in one manifold and two exhaust impulses in close succession in the opposite manifold, while the other four cylinders are fired in alternate relation from each bank and hence the exhaust impulses therefrom in each of the manifolds are spaced at twice the time interval.

In the conventional exhaust gas system wherein the exhaust gas stream from each manifold is conveyed through a sound-attenuating means or muffler and discharged through a tail pipe to the atmosphere, the irregular exhaust impulses in each manifold causes a throbbing or pulsing sound, the sound waves of which are difficult of attenuation and such sounds give an audible impression that the engine is not operating smoothly. Furthermore such irregular pulsations in the exhaust system set up a resonance reaction in the conventional sound-attenuating means or muffler which may audibly intensify rather than attenuate the sound waves of the pulsations.

The schematic illustrations of system and apparatus of the invention for blending the exhaust gas streams are shown with eight cylinder engines having two banks or blocks of four cylinders each. With particular reference to FIGURE 1 the outline of a top plan view of a vehicle body is illustrated at **20** which is carried upon a suitable frame structure (not shown) the vehicle being equipped with front and rear bumpers designated respectively **22** and **23**. Cradled in the forward region of the frame structure of the vehicle and supported thereby is an internal combustion engine **25** of the eight cylinder type having two banks or blocks of cylinders designated respectively **27** and **28**, each bank being inclusive of four cylinders.

The engine is connected through suitable transmission mechanism (not shown) for driving the vehicle wheels

in the conventional manner. The bank of cylinders **27** is provided with a manifold **32** with four branches connected with the exhaust openings in the engine block and through which exhaust gases from the cylinders are delivered into the manifold **32**.

The block portion of the engine containing the bank of cylinders **28** is provided with a manifold **34** substantially identical with manifold **32** having branches connected with the exhaust outlets of the cylinders **28** for conveying exhaust gases away from the engine. Thus each manifold conducts an individual exhaust gas stream from the engine.

In the arrangement shown in FIGURE 1, the manifold **32** is connected with an exhaust pipe **36** and the manifold **34** is connected with a similar exhaust pipe **38**, each of the exhaust pipes being arranged to convey its exhaust gas stream into a gas blending and sound-attenuating unit **40**.

As illustrated in FIGURE 1, the cylinders in the bank **27** are numbered **1** through **4** from the front to the rear of the engine and the cylinders in the bank **28** are numbered **5** through **8**. While several firing orders of the cylinders in an eight cylinder engine are possible, a typical firing of the cylinders occurs in the following order as numbered in FIGURE 1, viz. cylinders **1, 5, 4, 8, 6, 3, 7,** and **2**.

From this illustration of firing order, it will be noted that cylinders **2** and **1** of bank **27** of cylinders are fired successively and in the opposite bank **28**, cylinders **8** and **6** are fired successively. Thus the successive firing of cylinders **2** and **1** during engine operation produces two succeeding pressure impulses in the gases in the manifold **32** and the exhaust pipe **36**. In the opposite bank **28**, the firing of cylinders **8** and **6** in succession causes succeeding impulses in the gases in manifold **34** and the exhaust pipe **38**. When the remaining four cylinders are fired to complete a firing cycle, the successive ignition or firing of these cylinders occurs in alternate succession of cylinders in opposite banks.

Thus the lapsed time between the firing of cylinders **1** and **4** and between **3** and **2** in the bank **27** is greater than the lapsed time between the firing of cylinders **2** and **1**. Correspondingly, the lapsed time between the firing of cylinders **5** and **8** and between **6** and **7** is greater than the lapsed time between the firing of cylinders **8** and **6**.

Therefore in each manifold, there are two successive pressure impulses and two impulses occurring at greater time intervals during a complete firing cycle. Thus the pressure impulses in both exhaust gas streams delivered through the exhaust pipes **36** and **38** are irregular and when the gas streams are respectively directed through individual mufflers, objectionable audible throbbing or pulsing occurs. In the present invention the pulsations causing the throbbing are damped out or substantially equalized in a gas blending and sound-attenuating unit.

The gas blending and sound-attenuating unit **40** shown in FIGURES 1, 5 and 6 is in the form of an elongated chamber which may be positioned transversely of the vehicle construction as shown in FIGURE 1 or may be disposed lengthwise of the vehicle in the manner illustrated schematically in FIGURE 2. The structural arrangement of the gas blending and sound-attenuating unit **40** illustrated in FIGURES 5 and 6 is inclusive of an elongated hollow or tubular shell or shell construction **42** provided at its ends with closures or cover members **44** and **46**.

The shell construction is formed of sheet metal and may be of a single sheet of metal or a double layer shell of the character shown in FIGURES 5 and 6. In this form, the shell may be constructed of two sheets of metal designated **48** and **49** which are configurated to generally oval shape and have their adjacent end regions lapped and seamed as shown at **50**, or the shell may be formed of a single metal sheet rolled upon

itself to provide a multiple layer wall. One of the shells or layers such as the outer shell **49** may be formed with longitudinally extending, peripherally spaced recesses **52** which provide longitudinally extending ribs **54** in the manner shown in FIGURE 6. The depressed portions or recesses **52** of the metal of the outer shell engage the exterior surface of the inner layer or shell member **48** to position the major areas of the outer shell from the inner shell, the ribs or raised portions **54** forming with the inner shell longitudinally extending air chambers which assist in damping sound waves and in reducing shell noise.

The space between the inner and outer shell members **48** and **49** may be filled with a layer of asbestos or other heat resistant material such as a layer of rock wool or glass fibers having sound damping or sound-attenuating characteristics and also serves as heat insulation. If desired, the shell construction may be a single sheet of metal formed to tubular shape or a sheet of metal wrapped upon itself to form a double layer shell with overlapping end regions welded together.

In the shell construction illustrated in FIGURES 5 and 6, the recesses **52** terminate a slight distance from the ends of the shell and the end regions of the shell members **48** and **49** brought into contiguous relation to accommodate the end closures **44** and **46**.

Each of the end closures is formed with an oval shaped ledge **59** which fits within the end region of the inner shell layer **48**, each end closure being formed with a flange portion **61** which is bent around or spun into the shape shown in FIGURE 5 to form a gas tight seal between each of the end closures and the tubular shell construction.

The unit **40** is inclusive of gas passage means disposed within the shell provided with acoustic couplings for sound-attenuating purposes and for accommodating transverse or cross flow of gases within the shell construction to a gas outlet means. As particularly shown in FIGURE 5, each of the end closures **44** and **46** is formed with two openings defined by circular inwardly extending flanges **64**.

Two of the openings form gas inlet means and two of the openings form gas outlet means. Disposed within the flanged openings respectively are short tubular members, fittings or couplings **66**, **67**, **68** and **69**. Two of these couplings are connected respectively with the exhaust pipes **36** and **38** and the other two couplings are connected with gas discharge pipes or ducts **71** and **73** shown in FIGURE 1. The pipes or tubes **71** and **73** may be connected with mufflers or sound-attenuating units **75** and **76** of conventional construction. Each of the sound-attenuating units or mufflers **75** and **76** may be provided with an exhaust discharge tube or tail pipe **78** adapted to discharge the exhaust gases to the atmosphere.

In the embodiment illustrated in FIGURES 5 and 6 the gas passage means disposed within the shell **42** comprises two tubular members **80** and **82**. The gas passage tube or means **80** is in registration with the tubular coupling members **66** and **67** and may be supported thereby. The walls of the tubular gas passage means **80** are provided with a comparatively large number of small openings or open areas **84** which are spaced lengthwise and peripherally of the member **80** to facilitate transverse flow of gases through the openings into the interior of the shell.

The gas passage means or tubular member **82** is of similar character and its walls are provided with a comparatively large number of small openings or open areas **86** to facilitate transverse or cross flow of gases. The gas passage means **82** is in registration with and may be supported by the coupling members **68** and **69**. While the gas passage means illustrated in FIGURE 5 extend substantially the length of the shell between the end closures, the gas passage means may be formed of tubular members of lesser length as in forms of the invention hereinafter described.

The number and size of the openings **84** and **86** in the gas passage means are sufficient to facilitate or foster the interchange or cross flow of gases from one gas passage means to the other without setting up appreciable back pressure to the flow of gases. The openings or open areas **84** and **86** form acoustic couplings with the chamber defined by the shell **42** and the end closures **44** and **46** for attenuating sound waves entrained in the gas streams.

There is provided interiorly of the shell **42** one or more partitions or transversely extending walls which subdivide the interior of the shell into two or more compartments or chambers. As shown in FIGURE 5 there are three transversely extending walls or baffles designated respectively **90**, **92** and **94**, which are spaced lengthwise of the shell providing sound-attenuating and gas transfer chambers or compartments **95**, **96**, **97** and **98**. It has been found that by utilizing one or more transverse partitions or walls to subdivide the interior of the shell into compartments that improved sound-attenuation is obtained.

Each of the transversely extending walls **90**, **92** and **94** is preferably formed with a plurality of openings **100** shown in FIGURE 6 to facilitate transfer or flow of gases lengthwise of the shell from one compartment to another in addition to the gas passage areas provided by the perforations or openings **84** and **86** in the gas passage means.

In the arrangement shown in FIGURE 1 the exhaust pipes **36** and **38** may be connected respectively with the tubular coupling members **66** and **67** shown in FIGURE 5 whereby both exhaust gas streams from the manifolds **32** and **34** flow into the interior of the shell **42** through the inlet gas pressure means or tube **80**. The exhaust discharge tubes **71** and **73** shown in FIGURE 1 may be respectively connected with the tubular members or couplings **68** and **69** for conveying dual streams of exhaust gases from the unit **40** to additional sound-attenuating means or mufflers **75** and **76**.

The mufflers **75** and **76** may be of the conventional character utilized for attenuating sound waves in moving gas streams and each is provided interiorly with gas passage means formed with orifices forming acoustic couplings with the adjacent regions within the muffler for attenuating sound waves. As the details of construction of the muffler **75** and **76** form no part of the present invention they are illustrated only schematically in FIGURE 1.

Each of the transversely extending walls or baffles **90**, **92** and **94** is preferably formed with a peripheral flange **104** which snugly fits the interior surface of the inner shell **48**, and the central region of each of the walls may be formed with a raised disk-like portion **106** to lend rigidity to the walls. Each of the walls may be additionally provided with flanges **108** defining circular openings to accommodate the gas passage tubes or members **80** and **82**, the walls **90**, **92** and **94** providing additional support for the gas passage means **80** and **82**.

In the use of the gas blending and sound-attenuating unit **40** in the exhaust system exemplified in FIGURE 1, the gases from the exhaust pipes **36** and **38** flow into the gas passage means **80** thence transversely through the openings **84** in the tube **80** through the compartments **95**, **96**, **97** and **98** and the openings or open areas **86** into the gas passage tube **82** and are conveyed away from the unit **40** by the discharge tubes **71** and **73** into the mufflers or additional sound-attenuating devices **75** and **76**.

When the engine cylinders in alternate banks are fired in succession, there is an exhaust or pressure impulse set up in one direction through the gas passage means **80**, and the succeeding fired cylinder in an opposite bank sets up a pressure impulse in the gas stream in the opposite direction in the tube **80**. When two cylinders in one of the banks of cylinders are fired in succession, two succeeding pressure impulses are imparted to the gases in one direction in the gas passage tube **80** and the successive

firing of two cylinders in the opposite bank, two successive impulses are set up in the exhaust gas stream in the opposite direction in the gas passage tube **80**.

Without the use of the gas blending and sound-attenuating unit of the invention these successive impulses in one direction in a gas stream set up an audible throbbing and the sound waves accompanying these impulses cannot be satisfactorily attenuated in a conventional sound-attenuating means or muffler. In the system of the present invention, the pressures of the irregular impulses in the exhaust gas streams are substantially equalized within the unit **40** as the gases flow transversely through the sound-attenuating compartments and into the exhaust discharge gas passage means **82**.

The flow of gases from the gas passage tube **82** is smoothed out through the cross flow and pressure equalization of gases within the unit **40** and the objectionable sound waves which would normally cause throbbing are substantially nullified, damped out or attenuated through the acoustic couplings **84** and **86** in the gas passage means **80** and **82** and by the reaction forces of opposed pressure impulses in the gases moving in opposite directions in the gas passage means **80**.

Thus during the operation of an eight cylinder engine with which the exhaust system of the present invention is employed, there are successive reversals in direction of the flow of exhaust gases in the gas passage means **80** except when the two sets of successive pressure impulses occur in each manifold during a complete firing cycle of all of the cylinders of the engine.

The gas pressures between adjacent sound-attenuating and gas transfer chambers or compartments formed by the transversely extending partitions are substantially equalized through the provision of the openings **100** formed in the walls. It has been found that the openings or open areas **84** and **86** of about one-eighth of an inch diameter provide satisfactory acoustic couplings, the number of such openings being sufficient to permit the transverse flow of gases from the gas passage means **80** into the gas passage means **82** without setting up appreciable back pressure. It is found that the openings **100** may be about five-eighths of an inch in diameter, there being four openings in each wall as illustrated in FIGURE 6 to establish equalization of pressures in the several compartments in the unit.

FIGURE 2 is illustrative of a modified positioning of the gas blending and sound-attenuating unit **40** wherein the unit **40** is disposed lengthwise of the vehicle. The exhaust gases from the manifolds enter the unit **40** at one end and are discharged in dual streams through the other end of the unit. In this arrangement exhaust pipe **36'** may be connected with the coupling member or tubular member **68** and the exhaust pipe **38'** connected with the tubular member **66** shown in FIGURE 5.

The tubular members **67** and **69** then become outlet passages for the gas streams moving through the unit **40**, the outlet member **67** being connected with an exhaust conveying tube **110** and the outlet member **69** connected with an exhaust conveying tube **112**. These tubes may be connected with sound-attenuating mufflers **76'** and **75'** respectively, each muffler being provided with a tail pipe **78'**. In the arrangement of FIGURE 2, the dual exhaust gas streams enter the unit through the gas passage tubes **80** and **82** at one end of the shell and are discharged through the opposite ends of the tubes.

The gases moving through the unit **40** may flow transversely or crosswise from one gas passage means to the other through the openings **84** and **86** effecting a substantial equalization of the irregular pressure impulses in the exhaust gas streams whereby a more smooth flow of the gases from the unit **40** is attained. Substantial sound-attenuation occurs in the unit **40**, and particularly those sound waves set up by the irregular impulses occurring in each gas passage tube are substantially attenuated within the unit **40**.

When successive impulses occur in the exhaust stream moving through the tube **80**, the gas pressure is momentarily increased at each impulse causing increased flow of gases through the openings or open areas **86** into the adjacent chambers in which the successive impulses are cushioned or substantially neutralized. Thus there is a continuous blending or mixing of gases within the unit as they flow from one gas passage means to the other which substantially equalizes the differential pressures in the exhaust gas streams set up by the irregular pressure impulses occurring in the streams and the sound waves set up by such impulses are effectively attenuated.

FIGURE 3 is illustrative of an exhaust gas system of the invention embodying a gas blending and sound-attenuating unit **115** of the character illustrated in FIGURE 7. This form of unit **115** is inclusive of a shell **117** which may be of single or double wall construction as described in connection with the unit **40**, the shell illustrated in FIGURE 7 being of the double wall type. The shell **117** is equipped with end closures **118** and **120**, each being provided with an inlet opening and an outlet opening. The inlet openings accommodate exhaust inlet couplings or fittings **122** and **124** which are adapted to be connected respectively with the exhaust pipes **36''** and **38''** shown in FIGURE 3.

The end heads **118** and **120** are each provided with an outlet opening, the outlet in the end head **118** accommodating a coupling **126**, the outlet in the end head **120** accommodating a coupling **128**. Disposed in longitudinally spaced relation within the shell **117** are transversely extending walls or baffles **130**, **132** and **134**. Inlet gas passage means are disposed within the unit **115** for conveying exhaust gases from the dual exhaust streams into the interior of the shell **117**.

Arranged in registration with the inlet coupling **122** is a gas passage means in the form of a tubular member **136**, one end region of which extends into the coupling **122** carried by a flange **137**, defining the inlet opening in the end head **118**, and a flange **138** defining an opening in the transverse wall **130**. The periphery of the tubular gas passage means **136** is provided with a comparatively large number of small openings or orifices **140** which establish communication with a gas transfer and sound-attenuating chamber **142** defined by the end head **118** and the wall **130**.

The inlet fitting **124** carried by a flange **144** defining the inlet opening in the end head **120** and a flange **146** defining an opening in the wall **134** support the end regions respectively of a gas passage means or tube **148** as shown in FIGURE 7. The peripheral area of the tube **148** is formed with a comparatively large number of small orifices or openings **150** which establish communication with a sound-attenuating and gas transfer chamber **152** defined by the end head **120** and the wall **134**. The walls **130**, **132** and **134** define sound resonating chambers **154** and **156**.

The tubes **136** and **148** open into the chambers **154** and **156** respectively and these chambers serve as gas transfer means and to attenuate comparatively low frequency sound waves entrained in the exhaust gas streams. Arranged centrally and lengthwise of the chamber defined by the shell **117** is a tube **158** which extends through openings in the transverse walls **130**, **132** and **134**. The tube **158** establishes communication between the chambers **142** and **152** and serves to assist in the equalization of gas pressures in the chambers **142** and **152** resulting from the irregularity of pressure impulses in the exhaust gas streams.

The arrangement shown in FIGURE 7 is inclusive of a gas passage means or tubular member **160** for conveying exhaust gases from the interior of the unit **115** through the outlet fittings **126** and **128** into the exhaust tubes or ducts **162** and **164** shown in FIGURE 4. The exhaust gases may be conveyed through additional sound-attenuating means or mufflers **166** and **168** from which

the exhaust gases are discharged to the atmosphere through tail pipes 78".

In the form of construction shown in FIGURE 7, an exhaust outlet gas passage means or tube 160 is provided having its end regions in registration with the outlet fittings 126 and 128. The wall area of the gas passage tube 160 is provided with a comparatively large number of small openings 170 spaced lengthwise and peripherally of the tube 160 throughout substantially its entire area whereby communication is established with the chambers 142, 152, 154 and 156.

It will be apparent that the gases entering the inlet 122 from the exhaust pipe 36" may pass through openings 140 through chamber 142 and openings 170 into the gas passage tube 160, or through the chamber 154 and openings 170 into the tube 160. Gases entering the inlet tube 148 may pass through the openings 150, chamber 152 and openings 170 into the tube 160, or the gases may flow through the resonating chamber 156 and into the gas passage tube 160 through openings 170. The gases in chambers 142 and 152 may flow in either direction through the pressure equalizing tube 158.

Low frequency sounds are damped or attenuated in the resonators or chambers 154 and 156. Transfer of gases from the inlet tubes to the tube 160 may also be effected through the chambers 154 and 156 and through the openings 170 in communication with these chambers. The openings 140, 148 and 170 form acoustic couplings with the adjacent chambers in the shell 117 for attenuating intermediate and comparatively high frequency sound waves as well as to establish means facilitating transverse flow of exhaust gases from the inlet gas passage tubes to the outlet or discharge gas passage means.

In this form of construction, the transversely extending walls 130, 132 and 134 are otherwise imperforate except for the openings accommodating the inlet gas passage means 136, 148, the pressure equalizing tube 158, and the discharge gas passage tube 160.

The irregular gas pressures arising through irregular exhaust impulses imparted to the streams are substantially equalized within the unit 115 so that the exhaust gases discharged through the outlets in communication with the tube 160 flow more uniformly from the unit, and substantial ranges of sound waves of audible frequencies are attenuated within the unit whereby the additional attenuating means or mufflers 166 and 168, shown in FIGURE 3, are enabled to effectively attenuate remaining sound waves in the exhaust streams which are within the objectionable audible range.

Another form of gas blending and sound-attenuating unit of the invention is illustrated in FIGURES 4 and 8. In this form, the exhaust pipes 36*a* and 38*a* are connected with inlets in a gas blending and sound-attenuating unit 175. The unit 175 is inclusive of a tubular shell 177 which may be of double wall construction or single wall construction as heretofore described in connection with other forms of unit. The shell 177 is provided with end heads 178 and 180, the head 178 being provided with an inlet coupling 181 and an outlet coupling 182, and the end head 180 provided with an inlet coupling 184 and an outlet coupling 186.

Disposed centrally in the shell 177 and extending transversely thereof is a baffle or wall 188 which is provided with four openings 190 which are arranged in spaced relation similar to the arrangement of openings 100 illustrated in FIGURE 6. The openings 190 are approximately five-eighths of an inch in diameter although other size openings may be utilized to facilitate transfer of gases from one side of the wall 188 to the other to facilitate pressure equalization.

Spaced lengthwise from the central baffle or wall 188 are baffles 192 and 194 which with the central baffle 188 form chambers 195 and 196. These chambers provide for transfer of gases transversely of the shell as well as to function as resonating chambers for attenuating low

frequency sounds. The end head 178 and the baffle or wall 192 support a gas passage means 198, the peripheral wall area of which is provided with a comparatively large number of small openings 200.

Spaced transversely opposite the tube 198 is a gas passage means or tube 202, the end regions of which are supported by the end head 178 and the wall 192, the peripheral area of the tube 202 being formed with a comparatively large number of small orifices or openings 204. The end head 178 and wall 192 define a chamber or zone 206 which facilitates transverse flow of gases from the openings 200 into the tube 202 through the openings 204, the openings forming acoustic couplings in communication with the chamber 206 for attenuating intermediate range and high frequency sound waves.

Both of the gas passage means or tubes 198 and 202 open into the low frequency resonator and gas transfer means or chamber 195 so that some of the gases may flow transversely from tube 198 into the open end of tube 202 through the chamber 195. The inlet fitting or coupling member 184 is in registration with an inlet tube or gas passage means 210, the end of which opens into the chamber 196. The outlet fitting or member 186 is in registration was a gas passage means or tube 212, the end of which opens into the chamber 196 whereby gases may be transferred from tube 210 into tube 212 through the resonator chamber 196.

The peripheral wall or area of tube 210 is provided with a comparatively large number of small openings 214 and the peripheral area of the gas passage tube 212 is likewise provided with a comparatively large number of small openings 216. Thus some of the gases from the inlet tube 210 may flow through the openings 214 through the chamber 218 and into the tube 212 through the openings 216 providing an additional path for the transfer of gases from tube 210 into the tube 212. The chamber 218, defined by the end head 180 and the wall 194, provides a gas transfer and sound-attenuating chamber or compartment.

The openings 214 and 216 form acoustic couplings with the chamber 218 for attenuating medium range and high frequency sound waves. The installation of the unit 175 in the exhaust system is illustrated in FIGURE 4 wherein the inlet gas passage tubes 198 and 210 are respectively connected with the exhaust pipes 36*a* and 38*a* whereby the dual exhaust streams of gas are conducted into the unit 175 in opposing directions.

The outlet gas passage tubes 202 and 212 are connected respectively with exhaust conveying tubes 219 and 220 the exhaust tube 202 being connected with a discharge pipe 219 and the exhaust tube 212 connected with a discharge tube 220.

The pipes 219 and 220 are respectively connected with additional silencers or sound-attenuators 222 and 224 which are of conventional construction for attenuating sound waves that may be unattenuated in the unit 175, the exhaust gases from the mufflers 222 and 224 being discharged to the atmosphere through tail pipes 78*a*.

In the use of unit 175 in the exhaust system, the gas streams enter the inlet couplings 180 and 184 from each of the engine exhaust manifolds and the gases flow transversely to the discharge tubes 204 and 212 through the chambers 206 and 218 and through the transfer chambers 195 and 196. The chambers 206 and 218 through the medium of the small openings in the walls of the gas passage tubes serve to attenuate medium and high frequency sound waves and the chambers 195 and 196 function as resonator chambers to attenuate sound waves mostly of a low frequency range.

The openings 190 in the central baffle 188 provide communication between the resonator and gas transfer chambers 195 and 196 for equalizing gas pressures of the exhaust gas streams entering the unit 175 whereby the irregular pressure impulses in the incoming gas streams are substantially equalized or neutralized so that a

smoother flow of exhaust gases is obtained from the unit through the exhaust conveying tubes **219** and **220**.

Through this system the audible throbbing and pulsing sounds in the gas streams are substantially eradicated or damped out. In this manner the streams of gases conducted to the sound-attenuating mufflers **222** and **224** are endowed only with unattenuated sound waves of substantial regularity which are more readily attenuated in the muffler units **222** and **224** and thus all or substantially all of the objectionable sound waves in the audible range are attenuated either in the gas blending and attenuating unit **175** or in the mufflers or sound-attenuating units **222** and **224**.

Another form of sound-attenuating and gas blending unit **230** of the invention is illustrated in FIGURE 9, the construction being illustrated in schematic form. The unit **230** includes a shell **232** and end heads **234** and **236**. Each end head is provided with an inlet opening accommodating couplings **237** and **238** which are connected by means of a gas passage inlet means or tube **240**.

The end heads **234** and **236** are provided respectively with outlet couplings **242** and **244** which are connected by a gas passage means or tube **246** in registration with the couplings. Disposed centrally of the shell **232** is a transversely extending wall or baffle **250** provided with openings through which extend the gas passage tubes **240** and **246**. The central region of the baffle or wall **250** is provided with a comparatively large opening **252** for establishing communication between the chambers **254** and **256** formed by the end heads and the central wall **250**.

The inlet couplings **237** and **238** may be connected respectively with the exhaust pipes from the engine in the manner described in connection with other forms of the invention, and the outlet fittings **242** and **244** connected with discharge pipes or conduits for conveying exhaust gas streams away from the gas blending and sound-attenuating unit **230**. The exhaust conveying tubes may be connected with sound-attenuating mufflers or units which may be of conventional construction, the exhaust from the mufflers being discharged to the atmosphere through tail pipes.

The sound-attenuating and gas blending unit **230** may be comparatively short as for example ten or twelve inches in length and the central opening **252** in the baffle **250** may be approximately two and one half to three inches in diameter. The opening **252** should be of a size which permits or facilitates equalization of gas pressures in chambers **254** and **256** set up by the irregular firing impulses transmitted to the exhaust streams entering the unit **230**.

The tube **240** has its peripheral wall area provided with a large number of small openings **241** and the tube **246** likewise provided with a large number of small openings **247** to facilitate transverse flow of gases from one gas passage means to the other within the shell **232**. The openings **241** and **247** in the walls of the gas passage means form acoustic couplings with the chambers **254** and **256** for attenuating sound waves entrained in the gas streams.

It will be apparent from the foregoing description that in all forms of the combined gas blending and sound-attenuating unit, means are provided to foster or facilitate transverse flow of exhaust gases within the unit and, at the same time, sound waves of lengths that may be attenuated are eradicated within the unit and the irregular pressure impulses in the exhaust gas streams are smoothed out so that sound waves remaining unattenuated in the blending unit may be satisfactorily attenuated in the mufflers or additional attenuating units through which the exhaust streams may be delivered after they have been discharged from the gas blending unit.

In all forms of the gas blending and sound-attenuating unit, the number and size of openings in the walls of the gas passage means are provided sufficient to facilitate transverse flow of the gases without setting up appreciable back pressure or impediment to the incoming gases. It has been found that openings of about one-eighth of an inch in diameter in the walls of the gas passage tubes have been found satisfactory to provide for transverse flow of the gases and to provide acoustic couplings for attenuating sound waves entrained in the gas streams. The sound-attenuating and gas blending units are preferably of oval configuration such as that illustrated in FIGURE 6 in order to obtain as much vehicle road clearance as possible and facilitate the positioning of the unit close to the floor of the vehicle. The conventional mufflers or sound-attenuating units adapted to be connected with the exhaust streams discharged from the gas blending unit may be of the character shown in my prior Patent 2,661,073 granted September 6, 1955 or of other suitable conventional construction.

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

I claim:

1. A system for blending gases of dual gas streams and attenuating sound waves of the streams including an elongated chamber having an inlet opening in each end and an outlet opening at one end, pipes arranged to conduct gas streams through the inlet openings to the interior of the chamber, tubular gas passage means in the chamber connected with the inlet openings, the tubular gas passage means being formed with a plurality of spaced open areas, a second gas passage means in said chamber in registration with the outlet opening and being formed with a plurality of spaced open areas, the open areas forming acoustic couplings with the chamber for attenuating sound waves in the gas streams and facilitating transverse flow and blending of the gases of the streams within the chamber prior to their discharge through the outlet.

2. An exhaust system for an internal combustion engine having dual exhaust manifolds including an elongated chamber having an inlet opening in each end and at least one outlet opening in one end, pipes connecting the manifolds with the inlet passages respectively, gas passage means in the chamber in registration with the inlet passages including a tube, the wall of the tube being formed with a plurality of orifices, a second gas passage tube in the chamber in registration with the outlet opening, the wall of said second tube being formed with a plurality of orifices, transversely disposed longitudinally spaced walls in said chamber forming the same into compartments, said orifices forming acoustic couplings with the compartments for attenuating sound waves in the exhaust gas streams and facilitating transverse flow of exhaust gases from one gas passage means to the other to foster equalization of gas pressures within the chamber prior to the discharge of exhaust gases through the outlet.

3. A combined gas blending and sound-attenuating unit including an elongated casing having end closures forming a chamber, each closure being formed with an inlet and an outlet, said inlets adapted to accommodate flow of gases into the casing, tubular gas passage means in said casing connected with said inlets, tubular gas passage means in said casing connected with said outlets, means supporting said gas passage means in transversely spaced relation in said casing, the walls of said tubular gas passage means being formed with orifices providing for transverse flow and blending of gases within the chamber from the inlets to the outlets, said orifices forming acoustic couplings with the chamber for attenuating sound waves entrained in the gas streams.

4. A sound-attenuation system for use with dual exhaust gas streams from an internal combustion engine having dual manifolds including a sound-attenuating unit including a casing having end closures, each closure being

formed with an inlet and an outlet, ducts connecting the inlets with said dual manifolds respectively for conveying exhaust gases into the casing, tubular gas passage means in said casing connected with said inlets, tubular gas passage means in said casing connected with said outlets, means supporting said gas passage means in transversely spaced relation in said casing, the walls of said tubular gas passage means being formed with orifices providing for transverse flow of exhaust gases from the inlets to the outlets, said orifices forming acoustic couplings with the interior of the casing for attenuating sound waves entrained in the gas streams and assisting in blending nonuniform pulsations of the exhaust gases, and sound-attenuating means connected with each of the outlets formed in said end closures.

5. A sound-attenuation system for use with dual exhaust gas streams from an internal combustion engine having dual manifolds, a sound-attenuating unit including a casing having end closures, each end closure being formed with an inlet and an outlet, ducts connecting the inlets with said dual manifolds respectively for conveying exhaust gases into the casing, tubular gas passage means in said casing connected with said inlets, tubular gas passage means in said casing connected with said outlets, means including at least one transverse wall in said casing supporting said gas passage means, said wall having an open area to accommodate flow of gases therethrough, the walls of the tubular gas passage means being formed with a plurality of comparatively small openings providing for transverse flow of gases from the inlets to the outlets for blending the gases of the streams to equalize differential pressures in the gas streams, said openings forming acoustic couplings with the chambers formed by the casing and the transverse wall for attenuating sound waves entrained in the gas streams.

6. A sound-attenuation system for use with dual exhaust gas streams from an internal combustion engine having dual manifolds, a sound-attenuating unit including a casing having end closures, each closure being formed with an inlet and an outlet, ducts connecting the inlets with said dual manifolds respectively for conveying exhaust gases into the casing, a gas passage tube in said casing connected with said inlets, a second gas passage tube in said casing connected with said outlets, a transverse wall in said casing supporting said gas passage tubes, said wall having an open area to accommodate flow of gases therethrough, the walls of the tubular gas passage means being formed with a plurality of comparatively small openings providing for transverse flow of gases from the inlets to the outlets, said openings forming acoustic couplings with the compartments formed by the casing and the wall for attenuating sound waves entrained in the gas streams and sound-attenuating means connected with the outlets.

7. Apparatus for blending gases of sound entrained gas streams wherein pressure impulses are nonuniform including a casing provided with two inlets and two outlets, a first gas passage means in the casing in registration with the inlets, a second gas passage means in registration with the outlets, means in said casing forming a plurality of sound-attenuating chambers, said passage means being formed with open areas forming acoustic couplings with the sound-attenuating chambers and facilitating transfer of gases from the first gas passage means to the second gas passage means.

8. Apparatus for blending gases of sound entrained gas streams and attenuating sound including, in combination, an elongated casing having end closures, each of said closures being formed with a gas inlet and a gas outlet, a first walled gas passage means in registration with the inlets and a second walled gas passage means in registration with the outlets, a plurality of transversely disposed, longitudinally spaced members forming compartments in said casing, each of said gas passage means having a plurality of comparatively small openings formed in the walls thereof forming acoustic couplings with compartments in the casing for attenuating sound waves and providing for transverse flow of gases from the first gas passage means to the second gas passage means.

9. Apparatus for blending sound entrained gas streams wherein pressure impulses are nonuniform including, in combination, an elongated casing formed of sheet metal, end closures for the casing, each of said closures being formed with a gas inlet opening and a gas outlet opening, tubular means in alignment with the inlet openings, a tubular member in alignment with the outlet openings, longitudinally spaced, transversely arranged walls in said casing forming sound-attenuating chambers, the walls of the tubular means and member being formed with spaced peripheral open areas to accommodate transverse flow of gases from the tubular means to the member, said open areas forming acoustic couplings with the chambers for attenuating sound waves of the moving gases.

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