Nov. 1, 1960 F. E. DEREMER 2,958,389

SILENCER OR MUFFLER

Filed April 8, 1957

2 Sheets-Sheet 1

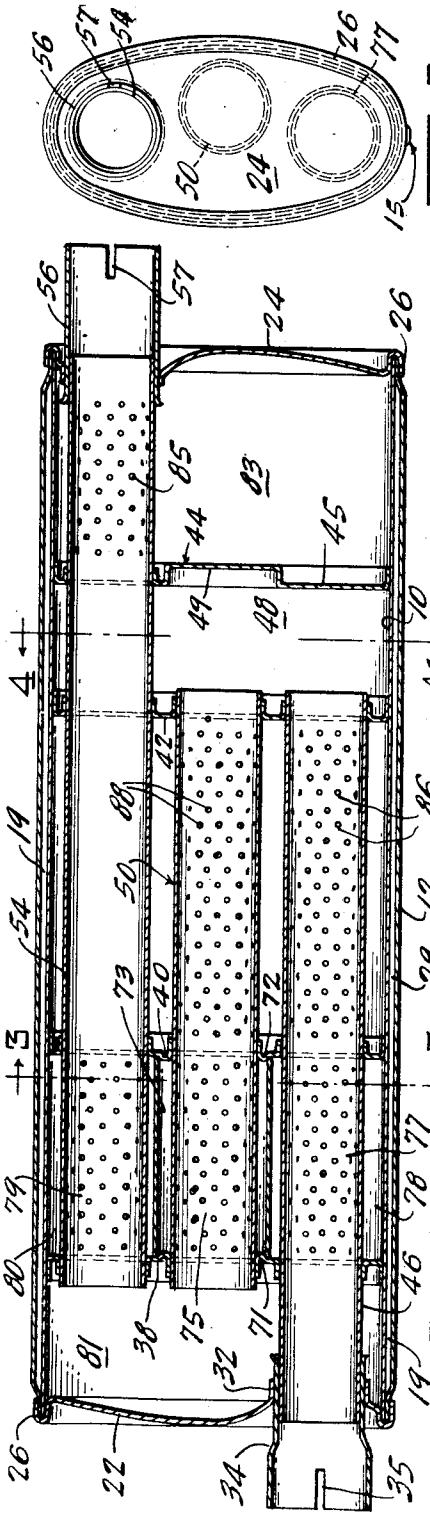


FIG-1-

FIG-2-

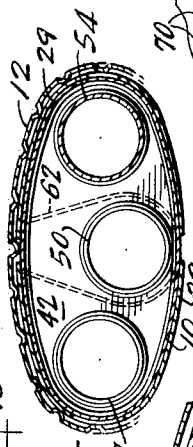


FIG-4-

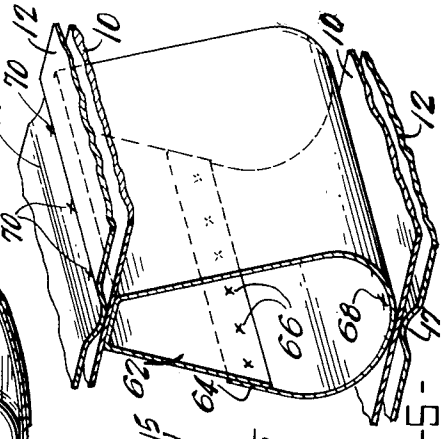


FIG-5-

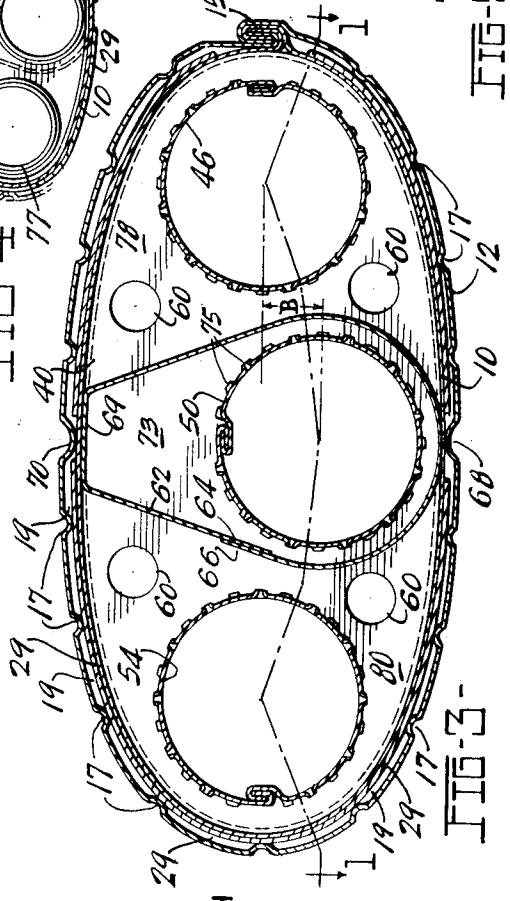


FIG-3-

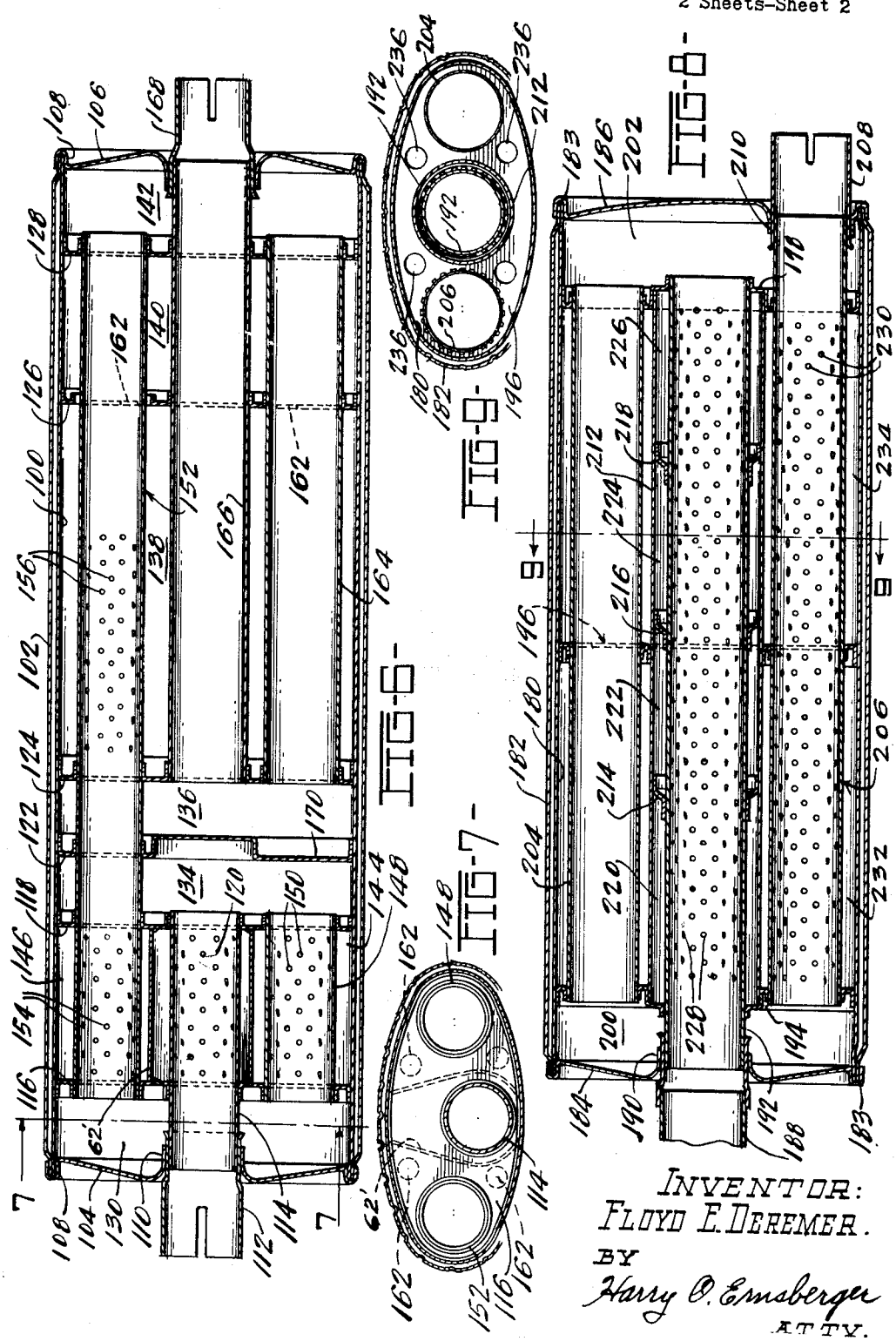
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Nov. 1, 1960 F. E. DEREMER 2,958,389

SILENCER OR MUFFLER

Filed April 8, 1957 2 Sheets-Sheet 2



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2,958,389

SILENCER OR MUFFLER

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Filed Apr. 8, 1957, Ser. No. 651,249

4 Claims. (Cl. 181—54)

This invention relates to sound attenuating or sound damping devices and more especially to sound attenuating devices, mufflers or silencers for use with the exhaust gas system or stream of internal combustion engines for damping, destroying or attenuating sound waves entrained in the exhaust gas stream.

Heretofore it has been conventional practice in the construction of mufflers for use with exhaust gas streams of internal combustion engines to provide the interior of the muffler with gas passage tubes in communication with high-frequency resonating chambers for damping or attenuating high frequency sound waves and to include in the muffler, one or more resonators or resonating chambers of the so-called "dead" types for damping or attenuating low frequency sound waves principally through sound absorption. Such low frequency resonator chambers are of the Helmholtz type which, in effect, provide sound traps in which the low frequency sound waves are substantially dissipated by absorption. The so-called "dead" chambers for attenuating low frequency sound waves are not in the path of the exhaust gas stream and the exhaust gases do not circulate therethrough although they are disposed whereby low frequency waves enter the chamber and are dissipated therein.

While sound attenuating arrangements or mufflers of this character have been extensively used, several disadvantages are inherent in such arrangements. For example, the length of the attenuating system is relied upon to attenuate the low frequency waves and the presence of one or more "dead" chambers necessarily limits or decreases the length of the sound attenuating system and hence the range of low frequency waves that may be successfully attenuated is reduced when the effective length of the attenuating system is shortened.

Another disadvantage of a "dead" sound trap chamber arrangement resides in substantial temperature differentials lengthwise of the muffler construction. The exhaust gases from an internal combustion engine are very hot, usually in excess of 1200° F., and this heat is readily transmitted from the exhaust gases to the walls of the gas passage tubes through which the gases flow and such metal walls become highly heated while the walls defining the "dead" chambers or Helmholtz type resonators remain relatively cool as the gases do not circulate therethrough. These extreme differentials in temperature in various regions or zones of a sound attenuating muffler result in the accumulation of moisture condensation in regions of reduced temperature in the muffler and, as the components of a muffler construction are usually fabricated of ferrous metals, oxidation and rusting ensues and in a comparatively short period of time the oxidation penetrates through and disintegrates the shell wall rendering the muffler ineffective for sound attenuating purposes.

The present invention embraces the provision of a muffler construction or sound attenuating means usable with moving gas streams wherein the gases of the stream are circulated throughout substantially all of the interior regions of the muffler construction and which embodies

means for attenuating low frequency sound waves without the use of "dead" chambers substantially isolated from the gas stream.

The invention has for an object the provision of a sound attenuating device or muffler construction wherein the sound attenuating system includes gas passage means and sound wave conveying means so arranged that sound waves are effectively attenuated, nullified or destroyed by being reflected or reverberated between the end heads of the muffler shell construction or between the end heads and baffle arrangements whereby substantially uniform temperatures are maintained throughout the entire interior region of the muffler.

Another object of the invention is the provision of gas passage means arranged in a muffler construction having end heads or closures and partitions or transverse walls so arranged in respect of the gas passage means that sound waves of low frequencies are caused to reverberate or bounce from one end head to the other or to a baffle whereby the low frequency sound waves are attenuated by wave interference with a minimum of attenuation by absorption.

Another object of the invention resides in the provision of a muffler construction embodying gas passage and sound conveying means of a substantial length, the interior components of the muffler construction being arranged whereby an increased range of sound waves or frequencies may be attenuated without enlarging the muffler construction.

Still another object of the invention is the provision of a multi-pass muffler in which the gas passage and baffle or partition means are arranged whereby substantially all interior portions or regions of the muffler construction are directly subjected to heat from the exhaust gas stream at sufficient temperatures to prevent or minimize the formation of moisture condensation within the muffler construction.

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 longitudinal sectional view of a muffler construction embodying a form of the invention, the section being taken substantially on the line 1—1 of Figure 3;

Figure 2 is an end view of the construction shown in Figure 1;

Figure 3 is a transverse sectional view taken substantially on the line 3—3 of Figure 1;

Figure 4 is a transverse sectional view taken substantially on the line 4—4 of Figure 1;

Figure 5 is an isometric view of a baffle means or intermediate shell forming an element of the muffler construction shown in Figure 1;

Figure 6 is a longitudinal sectional view of a muffler construction embodying another form of the invention;

Figure 7 is a transverse sectional view taken substantially on the line 7—7 of Figure 6;

Figure 8 is a longitudinal sectional view of a muffler construction illustrating another form of the invention, and

Figure 9 is a transverse sectional view taken substantially on the line 9—9 of Figure 8.

While the preferred arrangements of the invention as illustrated in the drawings are embodied in muffler constructions of the type or character especially adapted for attenuating or damping sound waves entrained in exhaust gas streams from an internal combustion engine, it is

to be understood that the principles of the invention may be utilized or embodied in other types of sound attenuator or silencer for attenuating sound waves of a moving gas stream.

The principles of the invention are embodied in a muffler construction of a type suitable for use with the exhaust gas system of an internal combustion engine, the construction being inclusive of a casing, housing or shell of tubular configuration having closed ends and provided with gas passage means and sound attenuating components, passages or resonating chambers within the muffler shell or casing or attenuating or alleviating sound waves and wherein the exhaust gases flow in paths or are distributed or dispersed throughout the interior of the muffler shell or casing wherein so-called "dead" chambers are eliminated with a consequent improvement in the distribution of heat throughout the various regions of the muffler and an attendant improvement in sound attenuating or damping characteristics.

Referring to the drawings in detail, and first with particular reference to the arrangement shown in Figures 1 through 5, the shell casing or housing construction of the muffler is preferably of the double wall type comprising an inner wall or layer **10** and an outer wall or layer **12**, said shell walls being formed of sheet metal and preferably each as an independent sheet. The shell components or walls **10** and **12** are preferably spaced in the manner shown in Figure 3 and the meeting or edge regions of the metal layers or sheets are folded or bent upon themselves to form an interlock as at **15**, and the folded or bent portions of the metal sheets being crimped to form a fluid tight seam or juncture extending lengthwise of the muffler construction.

While the arrangement of the invention may be embodied in a muffler construction embodying a single walled casing or shell, it is found that a double walled arrangement of the character disclosed herein improves the reduction or elimination of so-called "shell" noise. As particularly shown in Figures 2, 3 and 4, the cross sectional configuration or shape of the muffler construction or shell is generally oval or ellipsoidal, but it is to be understood that the shell or casing configuration may be circular or polygonal in cross section if desired.

While the shell or casing construction illustrated herein is formed of two sheets of metal, the shell may be fabricated of a single metal sheet rolled upon itself with overlapping end regions of the sheet welded to provide a seam and a double or multiple wall construction.

In the illustrated embodiment of Figures 1 through 5, the outer metal layer, wall or sheet **12** is formed with peripherally spaced indentations, depressions or recesses **17** which provide inwardly extending ridges or lands extending longitudinally of the muffler shell or casing and form longitudinally arranged chambers or confined zones **19**.

The shell or casing construction is provided with end walls, heads or closures **22** and **24**, each of the heads or closures being formed with a peripheral flange arrangement **26** of generally U-shaped cross section forming a peripheral recess or groove which receives the mating or engaging end regions of the shell walls **10** and **12** in the manner shown in Figure 1.

It should be noted that the end regions of the walls **10** and **12** are brought into contiguous engagement and are embraced in the recess provided by the flange construction **26**, the latter being crimped so as to form a fluid-tight juncture between the ends of the shell construction and the end heads or end walls **22** and **24**. The chambers or confined zones **19**, provided between adjacent ridges formed by the depressed portions or recesses **17** of the outer wall or layer, provide individual chambers extending lengthwise of the shell and substantially isolated one from another whereby there is little or no circulation of air between the shell walls peripherally of the shell construction.

The longitudinally extending chambers **19** are completely isolated from the interior region defined by the inner wall of the shell construction, the confined zones or chambers **19** forming individual air spaces or air cushions which assist in reducing shell noise or vibration which may be set up or established by flow of exhaust gases through the muffler shell.

In certain installations of muffler construction, it may be desirable to provide a non-metallic heat insulating medium or layer between the shell walls in order to further reduce sound transmission as well as to minimize radiation of heat from the muffler shell. As shown in Figure 3, a sheet or layer **29** of heat resistant material such as asbestos or mineral fibers such as glass fibers may be disposed so as to extend throughout subtantially the entire perimeter of the muffler shell as shown in Figure 3 or may extend over a portion of the region between the shell walls if desired.

The end wall or head **22** formed of sheet metal is provided with a circular flange **32** defining an opening adapted to accommodate a coupling sleeve or tubular fitting **34** extending therethrough in the manner shown in Figure 1. The portion of the fitting exterior of the muffler end head is formed with a slot **35** and a clamping means (not shown) is applied to this region of the fitting **34** to draw the fitting into snug engagement with an exhaust tube or pipe from an engine or other tube adapted to conduct a moving gas stream into the muffler.

In the arrangement illustrated in Figure 1 the fitting **34** serves or functions as a portion of an inlet gas passage means for conveying exhaust gases into the interior of the muffler construction. Spaced from the end head **22** is a transversely extending partition, wall or header **38** and spaced from the header **38** is a second header, wall or partition **40** of substantially the same configuration as the partition **38**.

Disposed within the muffler shell construction are additional transversely extending headers or partitions **42** and **44** disposed in spaced relation as illustrated in Figure 1. Telescoped with a region of the tubular inlet fitting **34** is an inlet tube **46** forming a gas passage means within the muffler shell, the partitions **38**, **40** and **42** being formed with flanged openings to snugly receive and accommodate the gas passage tube **46** as shown in Figure 1. The innermost end of the tube **46** is in communication with a transversely arranged gas passage or chamber **48** defined or formed by the partitions or headers **42** and **44**.

The headers or walls **38**, **40** and **42** are formed with flanged openings to snugly receive and accommodate a second or intermediate gas passage tube **50** which forms a gas passage or gas conveying means through which the gases are retroverted toward the inlet end of the muffler. The headers or partitions **38**, **40**, **42** and **44** are formed with flanged openings to receive a tube or conduit **54** which forms a gas passage outlet means in the muffler shell.

The end head **24** is formed with an opening to receive a tubular outlet fitting **56** which is telescoped with an end region of the gas passage discharge tube or means **54** as shown in Figure 1. An end region of the fitting **56** is provided with a slot **57** and a clamping means (not shown) is adapted to surround the slotted region of the fitting to clamp the same in engagement with a tail pipe or other tubular means for conveying exhaust gases away from the muffler construction.

As particularly shown in Figure 3, the header or wall **40** is formed with a plurality of openings **60**, there being four openings in the header in the embodiment illustrated, the openings **60** facilitating movement of gases as hereinafter described.

It should be noted that the axis of the intermediate gas passage tube **50** is substantially offset as indicated at B in Figure 3 from a plane through the axes of the gas passage tubes **46** and **54**. Disposed between the headers

38 and 40 and extending across the inner space defined by the inner shell wall 10 and surrounding the portion of the gas passage tube 50 between the partitions 38 and 40 is an intermediate shell or baffle means 62 which is generally of tear-drop or pear shape in cross section as in Figures 3, 4 and 5. The baffle or intermediate shell 62 is formed of a single sheet of metal, the end regions overlapping as at 64 and being secured together by spot welds 66 or other suitable joining means.

The curvilinear portion of the shell 62 is joined to the shells by means of spot welds 68 and the opposite region 69 of the shell is spot welded as at 70 to the shell walls. During the application of the spot welds 68 and 70 the material of the outer shell at the region of the weld is brought into contiguous or welding contact with the inner shell wall 10, the latter being in contact with the intermediate shell 62 so that the shell walls 10 and 12 at these regions are welded together and to the intermediate shell 62.

The transversely extending members or walls 38 and 40 are respectively formed with shoulders 71 and 72 of the same contour or shape as the cross sectional configuration of the baffle member 62. The baffle member 62 is adapted to engage the shoulder portions 71 and 72 forming a tear-drop or pear-shaped sound resonating chamber 73 surrounding a perforated region 75 of the intermediate tube 50.

The member 62 provides an intermediate shell or baffle which with the partitions or headers 38 and 40 define the chamber 73, the baffle means 62 preventing the direct transverse flow or passage of exhaust gases from the openings 77 formed in the region of the wall 46 between the partitions 38 and 40 and the openings 79 formed in the wall of the region of the tube 54 disposed between the headers or partitions 38 and 40. The baffle 62 thus forms high frequency resonating chambers 78 and 80.

The partition or header 38 and the end head or closure 22 at the inlet end of the muffler construction define a transversely arranged chamber or passage 81 for effecting the flow or transfer of exhaust gases from an end of the tube 50 into the tube 54 so that there is a continuous circulation of exhaust gases in the transverse passage 81. As the region of the tube 46 between the partition or header 38 and the end closure 22 is imperforate, the exhaust gases which move through the passage 81 must first flow in a right-hand direction through the tube 46 as viewed in Figure 1 thence in a retroverted or left-hand direction through the tube 50 before passing into the outlet tube 54.

It will be apparent from Figure 1 that all of the exhaust gases moving through the muffler construction are retroverted through at least a portion of the length of tube 50 before they are discharged through the outlet pipe or passage 54.

The partition or transversely extending wall 44 together with the end head or closure 24 at the discharge end of the muffler construction define a chamber 83 which is in communication with a region of the tube 54 by means of a large number of small openings or apertures 85 formed in that portion of the wall of tube 54 disposed between the partition 44 and the end closure 24. The chamber 83 forms a sound attenuating means or chamber. The exhaust gases continually circulate through chamber 83, flowing into and out of the chamber 83 through the openings 85.

It should be noted that in the arrangement shown in Figure 1 there are no chambers or sound attenuating regions which are isolated against circulation or flow of exhaust gases so that the exhaust gases traverse all the internal regions and passages in the muffler construction. One of the salient features of the invention is the elimination of resonator chambers which are substantially isolated from the moving exhaust gases as in prior muffler arrangements.

In muffler constructions embodying isolated sound attenuating chambers of the so-called Helmholtz resonator type, very high temperature differentials exist within such a muffler construction whereby certain regions become intensely hot by reason of direct contact with the intensely hot exhaust gases while other regions of the muffler construction which are out of the path of flow of exhaust gases are of much lower temperatures.

The differential temperatures were of sufficient magnitude in prior muffler constructions as to foster the condensation of moisture in regions of lower temperature in the muffler.

The formation of moisture condensation persisted by reason of the lack of flow of exhaust gases throughout the entire interior regions of the muffler. Hence within comparatively short periods of time, the collected moisture condensation resulted in oxidation of the ferrous metal walls of the muffler causing disintegration of the shell walls.

In the arrangement of the present invention, the gases flowing through the gas passages and chambers within the muffler traverse substantially all of the interior regions of the muffler whereby substantially uniform temperatures are maintained throughout the entire length of the muffler.

Thus the elimination of regions of reduced temperature within the muffler prevents the formation and accumulation of moisture condensation as the heat of the exhaust gases and the fact that exhaust gases flow throughout the entire interior regions of the muffler volatilize and carry away the moisture thus preventing "puddling" of moisture or water within the muffler.

Some of the gases moving in a right-hand direction through the tube 46 flow transversely through openings 86 formed in the wall of tube 46 between the partitions 40 and 42 into openings 88 formed in an adjacent wall portion of the gas passage tube 50 whereby some of the exhaust gases bypass the transverse passage 48. The passages or chambers defined by the partitions 38, 40, 42, 44 and the end closures 22 and 24 provide sound attenuating chambers or passages for damping or attenuating sound waves.

The paths of flow of exhaust gases through the muffler are as follows: The gases from an exhaust system enter the inlet tube 46 and some of the gases flow through the openings 77 in pipe 46 into the high frequency resonating chamber 78. Incoming exhaust gases in the inlet pipe 46 may flow transversely through the openings 86 into the openings 88 formed in the wall of tube 50 while other gases from the inlet tube flow transversely through the connecting passage or chamber 48 and then flow in a reverse or retroverted direction through the intermediate tube 50 into the transverse passage 81 thence into the outlet pipe 54. Gases entering the discharge tube 54 may flow through openings 79 into and circulate through the resonating chamber 80.

The exhaust gases moving through the outlet tube 54 may flow into and circulate through the passage or chamber 83 through the openings 85 formed in the wall of tube 54. Gases in the region between the partitions or headers 40 and 42 may flow into the regions between the partitions 38 and 40 at either side of the tear-drop shaped baffle or shell 62 through comparatively large openings 60 shown in Figure 3 formed in the partition or wall 40.

The chamber regions transversely of the gas passage means or tubes 46, 50 and 54 form high frequency sound attenuating chambers which are acoustically coupled with the gas passage means through the small openings in the tube walls for damping or attenuating high frequency sound waves.

An important feature of the muffler construction of the present invention involves the attenuation, destruction or nullification of low frequency sound waves by reverberation or reflection so that the low frequency waves are caused to interfere with one another and thus

affect or eliminate the low frequency sounds. For example, low frequency sound waves entrained in the exhaust gases moving in a right-hand direction through the inlet pipe or gas passage **46** impinge upon a flat portion **45** of the partition or wall **44** and are reverberated or reflected in a reverse direction toward succeeding incoming sound waves in the inlet tube **46**.

Through this method, reverberated waves reflected from or bouncing off of the surface **45** establish interference with succeeding incoming sound waves so that certain frequency waves are attenuated or nullified by the interference through the wave reverberation in the inlet pipe **46**. The same wave attenuating action is prevalent in reference to low frequency sound waves moving from the chamber **48** through the intermediate gas passage tube or means **50** into the transverse passage or connecting chamber **81**.

Thus sound waves moving through the tube **50** impinge upon the end wall or end closure **22** of the muffler and are reverberated in a right-hand direction through the passage **50** and establish interference with sound waves entering and moving through the tube **50** from the transverse connector or passage **48**. In this manner, sound waves of certain low frequencies are attenuated within the passage **50** and repeated reverberation of sound waves takes place between the flat surface **49** of the partition **44** and the region of the closure **22** aligned with the tube **50**.

Through this arrangement, a substantial range of low wave frequencies is attenuated in the gas passage tube **50** between the surface **49** and the end wall **22**. In reference to the temperatures in various regions of the muffler construction, a substantial portion of the intensely hot incoming exhaust gases move in a right-hand direction through the inlet tube **46** and the heat of these gases or a substantial amount of heat therefrom is transferred by direct contact to the transverse wall or partition **44**.

This factor assists in increasing the heat transferred to the regions of the muffler construction defining the chamber **83** to augment or increase the temperature to supplement the heat transferred from the cooler exhaust gases which flow through the openings **85** in the wall of the outlet tube **54** and circulate through the chamber **83**.

Through this method of flowing exhaust gases through all interior regions of the muffler effecting transfer of heat to the partitions and transverse passages, only minor variations in temperature occur throughout the entire interior of the muffler construction. Furthermore it is found that attenuation or damping or sound waves of low frequency is improved over an increased range through the reverberation and wave interference system without increasing the length of the paths of travel of the exhaust gases through a retroverted type or multiple pass muffler.

The arrangement shown in Figures 6 and 7 involves multiple gas passage and sound wave traversing means whereby the path of traverse of the exhaust gases and entrained sound waves is substantially increased without increasing the length of the muffler construction and wherein exhaust gases are circulated throughout the entire interior regions of the muffler so as to provide for substantially uniform temperatures throughout all interior regions of the muffler.

The muffler construction shown in Figures 6 and 7 includes an inner shell **100** and an outer shell **102** which are of substantially the same construction and configuration as the corresponding walls **10** and **12** of the arrangement shown in Figure 1. The muffler construction is inclusive of end heads, walls or closures **104** and **106**, each end closure being provided with a peripheral flange construction **108** of generally U-shaped configuration in cross section which embraces the adjacent end regions of the inner and outer shell walls **100** and **102**. The flange arrangement **108** is crimped or pressed into snug engagement with the shell walls to provide a gas tight seal.

In this form of construction the inlet and outlet gas passage means are disposed generally centrally of the muffler and offset or laterally disposed with respect to a plane through other gas passage means in the muffler construction.

The end head **104** is formed with an opening defined by a flange **110** which receives and accommodates a tubular coupling or fitting **112** at the inlet end of the muffler, the fitting **112** adapted to be connected with an exhaust duct for an internal combustion engine or the like.

Telescoped within the fitting **112** is a gas passage or gas inlet tube **114** which extends through transversely arranged partitions or walls **116** and **118**, the partitions **116** and **118** being substantially of the same configuration as the partitions or walls **38** and **40** shown in Figure 1.

Disposed between the partitions **116** and **118** is a tear-drop shaped baffle or intermediate shell **62'** of the same shape and construction as the member **62** shown in Figure 3. In the arrangement shown in Figure 6, the intermediate tear-drop shaped shell **62'** surrounds a perforated region **120** of the inlet pipe **114**.

The muffler arrangement shown in Figure 6 is inclusive of transversely arranged partitions, walls or headers **122**, **124**, **126** and **128**. These partitions together with partitions **116** and **118** and the end closures **104** and **106** define transversely arranged gas passages or chambers **130**, **134**, **136**, **138**, **140** and **142**. The partitions **116** and **118** together with the tear-drop shaped intermediate shell **62'** define high frequency resonating chambers **144** and **146**.

A comparatively short tube **148** establishes gas passage means between the chambers or transverse passages **134** and **130**, the incoming gases entering the muffler through the tube **114** traversing the passage **134**, then flow in a reverse direction through the tube **148** into the transverse passage **130**. The walls of the tube **148** are formed with a plurality of small openings or apertures **150** which form acoustic couplings with the high frequency resonating chamber **144** for attenuating high frequency sound waves.

A gas passage means or tube **152** extends through openings provided in the transverse partitions whereby to establish communication between the chambers or transverse passages **130** and **142** disposed adjacent the respective end closures **104** and **106** of the muffler construction. The portion of the tube **152** disposed between the transversely extending partitions **116** and **118** is formed with a plurality of small orifices or apertures **154** which form acoustic couplings between the interior of the tube **152** and the high frequency resonating chamber **146** for attenuating high frequency sound waves.

A substantial length of the wall of tube **152** disposed between the transversely extending partitions **124** and **126** is formed with a plurality of small circular openings or apertures **156** which form acoustic couplings with the chamber **138** defined by the partitions **124** and **126**. Thus exhaust gases flow through the openings **156** and circulate through the resonating chamber **138**.

The partition **126** is formed with a plurality of comparatively large openings **162**, shown in Figure 7, establishing means facilitating the circulation of exhaust gases from chamber **138** into and through the chamber **140**.

Extending through openings provided in the partitions or transversely extending walls **124**, **126** and **128** is a gas passage tube **164** to conduct or transfer exhaust gases from the end chamber or transverse passage **142** into the transversely extending passage **136** so as to facilitate discharge of exhaust gases through an outlet passage or tube **166**. The extremity of the outlet tube **166** adjacent the end closure **106** is telescoped with an outlet fitting **168**

of the same construction as the inlet fitting or coupling member **112**.

The general path of travel of gases through the muffler is as follows: The gases entering the inlet tube **114** flow through transverse passage **134** into the tube **148** and through the tube **148** into transverse passage **130**. The gases in the passage **130** flow substantially the length of the muffler through the tube **152** into the transverse passage **142** thence in a reverse direction through the passage or tube **164** into the transverse passage or chamber **136** and from this passage or chamber are discharged from the muffler through the outlet passage or tube **166**.

It will thus be apparent from the foregoing that the gases traverse a system of passages of substantial length so that sound waves of a substantially wide range of frequencies are attenuated in the muffler construction.

It will also be apparent that the openings or apertures **120**, **150**, **154**, **156** and the larger openings **162** in the partition **126** facilitate the circulation of exhaust gases throughout the various chambers and passages in the muffler construction whereby a substantially uniform temperature may be maintained throughout all of the interior regions of the muffler. In this arrangement there are no so-called "dead" chambers as far as the circulation of exhaust gases is concerned as the gases are enabled to circulate throughout all regions of the muffler.

The arrangement of Figures 6 and 7 provides for the reflection of reverberation of sound waves of lower frequencies between pairs of walls, partitions and end heads whereby sound wave interference is established to attenuate or eliminate sound waves of lower frequencies.

Thus sound waves entrained in the gas stream moving through the tube **148** are reverberated or reflected between the end head **104** and a portion **170** on the partition **122** whereby sound waves of certain frequencies are attenuated by wave reverberation and interference.

The low frequency sound waves moving through the gas passage or tube **152** are reverberated or reflected between the end heads **104** and **106** of the muffler and are attenuated or destroyed by wave interference. Certain sound waves entrained in the gas stream moving through the gas passage tube **164** are attenuated and eliminated by wave interference through reflection or reverberation of the waves between the end head **106** and the wall portion **170** of the partition or transverse header **122**.

From the foregoing it will be seen that the exhaust gases and entrained sound waves move through several passage means of various lengths whereby effective sound attenuation is attained over a wide range of sound frequencies, and that the exhaust gases are enabled to circulate throughout all interior regions of the muffler so as to foster the establishment of substantially uniform temperatures throughout all regions of the muffler.

By offsetting the inlet pipe **114** relative to a plane through the axes of the gas passage tubes **148** and **152**, the inlet tube **114** may be disposed adjacent a region of the muffler shell so as to enable the positioning of the muffler close to the floor of a vehicle in which the muffler may be installed without interference with cross frame members adjacent the vehicle floor. The outlet tube **166** may also be positioned in alignment with the inlet tube **114**.

Another form of the invention is illustrated in Figures 8 and 9. In this form the outer shell construction is inclusive of an inner wall or layer **180** and an outer layer **182** of the same character as illustrated in the other forms of muffler construction disclosed herein. The end regions of the inner and outer layers or shells **180** and **182** are engaged by peripheral flange portions **183** formed on the end heads **184** and **186** as shown in Figure 8.

A tubular fitting **188** extends through an opening in the end head **184** defined by a flange **190** and is in telescoping relation with an end region of a gas inlet passage means or tube **192** which extends substantially full length of the muffler construction. Disposed transversely of the muffler construction and spaced lengthwise thereof are interior walls or partitions **194**, **196** and **198**.

The end head **184** and the partition **194** define a transversely arranged gas passage or chamber **200**, and the end head **186** with the partition **198** define a transversely arranged gas passage or chamber **202**. The extremity of the gas inlet passage means or tube **192** terminates in the transverse passage **202**. The intermediate wall or partition **196** forms an intermediate or central supporting means for the gas passage tubes disposed in the muffler.

Extending through openings in the partitions **194**, **196** and **198** is a second gas passage tube **204** which establishes communication between the transversely arranged gas passages or flow connectors **200** and **202**.

The walls **194**, **196** and **198** are also provided with openings through which extends a gas passage means or tube **206** which forms a gas outlet or discharge means. The end of the outlet tube **206** adjacent the end head **186** is telescoped with an outlet tube or fitting or extension **208** which projects into or through an opening formed in the end head **186** and defined by a flange **210** as shown in Figure 8.

Surrounding the inlet gas passage means or tube **192** is a cylindrical sleeve or member **212** which extends between the partitions or walls **194** and **198** providing a chamber region surrounding the inlet tube **192** and having its ends closed by means of portions of the walls **194** and **198**.

Spaced lengthwise of the inlet tube **192** in the region between the wall of the tube and the sleeve or member **212** are partitions or walls **214**, **216** and **218** which, with the walls **194** and **198**, define high frequency resonating chambers **220**, **222**, **224** and **226**. The region of the wall of the inlet tube **192** between the partitions **194** and **198** is formed with a plurality of small openings or apertures **228** which form acoustic couplingss with the high frequency resonating chambers **220**, **222**, **224** and **226** which function to attenuate high frequency sound waves entrained in the gas stream. The openings or apertures **228** also facilitate the circulation of exhaust gases through the high frequency resonating chambers.

The wall of the gas outlet or discharge tube **206** in the region between the partitions **194** and **198** is formed with a large number of comparatively small openings or apertures **230** which establish acoustic couplings with the chambers **232** and **234** defined by the transversely extending walls **194**, **196** and **198**. The chambers **232** and **234** form sound attenuating chambers for intermediate frequency sound waves moving through the gas outlet tube **206**.

The centrally disposed partition or wall **196** is provided with openings **236** shown in Figure 9 to facilitate or foster the circulation of exhaust gases through the chambers **232** and **234**.

In the arrangement shown in Figures 8 and 9, the exhaust gases flow into the inlet tube **192** in a right-hand direction as viewed in Figure 8, thence transversely through the passage **202** and into the intermediate tube **204**. The gases flow in a reverse direction through the tube or gas passage means **204** into the transverse passage or chamber **200**. The gases flow transversely through the passage **200** and into the exhaust discharge outlet tube **206**, the gases moving through the outlet tube **206** in the same direction as the gases flowing through the inlet tube **192**.

In this arrangement the gases are retroverted through the muffler so that a comparatively long path of traverse is provided through the medium of the tubes **192**, **204** and **206** thus permitting the attenuation of a large range of sound frequencies. Furthermore the exhaust gases may flow through the high frequency resonators or resonating chambers **220**, **222**, **224**, and **226** through the

provision of the large number of openings **228** in the inlet pipe **192**.

The exhaust gases moving in the outlet tube **206** may flow through the large number of orifices **230** into the chambers **232** and **234**, there being communication between the latter mentioned chambers through the provision of the openings **236** formed in the centrally disposed partition or wall **196**. It will thus be apparent that the exhaust gases are permitted to flow through all regions in the interior of the muffler, a condition which fosters the establishment of uniform temperature conditions throughout the entire interior of the muffler.

Some of the low frequency sound waves entrained in the gas stream impinge upon the end head **186** and are reverberated or reflected in a reverse direction through the tube **192** so as to establish wave interference with incoming sound waves and thereby attenuate or destroy sound waves by wave interference. Sound waves in the gas stream moving through the retroverting tube **204** are reflected or reverberated by the end heads **184** and **186** to establish wave interference in this tube to attenuate or destroy sound waves of comparatively low frequencies.

There are no so-called "dead" chambers of the Helmholtz type in the construction shown in Figures 8 and 9 as the gas passage means and orifices in walls of the gas passage means facilitate the flow of exhaust gases throughout all interior regions of the muffler and are not trapped or isolated in any portion of the muffler construction.

In all forms of the invention the flow of exhaust gases through the muffler passages and chambers is such as to establish substantially uniform temperatures throughout all regions of the muffler to thereby prevent the formation of moisture condensation or accumulation as there are no isolated regions of reduced temperature in the muffler constructions. This factor substantially eliminates oxidation or rusting of the components and shell walls thus prolonging the useful life of the muffler construction as compared with mufflers heretofore utilized embodying "dead" chambers.

It is also found that the arrangement of the present invention improves the attenuation of an increased range of sound wave frequencies through wave interference as compared with the sound attenuating efficiency of mufflers embodying the so-called "dead" chambers wherein attenuation is attained through absorption.

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 sound attenuating means for use with a gas stream including, in combination, a tubular shell of oval cross-section, closure walls secured to the ends of the shell, said closure walls being respectively provided with gas passage tubes forming gas inlet and outlet means, a third gas passage tube in said casing in transverse overlapping relation with said inlet and outlet tubes, intermediate walls in said shell, one of said tubes being disposed with its axis offset from a plane passing through the axes of the other tubes, an intermediate tubular shell of pear-shaped cross-section surrounding a region of the offset tube and extending between and secured to transversely opposed portions of the tubular shell, the wall region of the tube surrounded by the intermediate shell being formed with a plurality of small openings providing acoustic couplings between the same and the interior of the intermediate shell, at least one of said end closure walls and intermediate walls forming two longitudinally spaced transverse gas passage means providing for transverse flow of gases from an end of one tube to an end of another tube, one of the walls of one of said transverse passage means being imperforate and arranged whereby sound waves entrained in the gas stream and moving lengthwise of the gas passage tubes are impinged upon the imperforate wall and reverberated through the tubes and attenuated by wave interference.

2. A sound attenuating means for use with a gas stream including, in combination, a tubular shell, closure walls secured to the ends of the shell, said closure being respectively provided with gas passage tubes forming gas inlet and outlet means, a third gas passage tube in said shell in transverse overlapping relation with said inlet and outlet tubes, intermediate walls in said shell, one of said tubes being disposed with its axis offset from a plane passing through the axes of the other tubes, a tubular baffle means of pear-shaped cross-section surrounding a region of the offset tube and extending between and secured to opposed portions of the tubular shell and defining with the adjacent intermediate walls a plurality of high frequency resonating chambers, the wall regions of the tubes adjacent the baffle means being formed with a plurality of small apertures providing acoustic couplings between the tubes and the resonating chambers, certain of said intermediate walls and at least one of said end closure walls forming two longitudinally spaced transverse gas passage means providing for transverse flow of gases from an end of one tube to an end of another tube, the walls of said transverse passage means, the intermediate walls and the openings in the tubes being arranged whereby the gases circulate through all regions interiorly of the shell to establish more uniform temperatures throughout all regions of the shell.

3. A sound attenuating means for use with a gas stream including, in combination, a double walled tubular casing of oval cross-section, closure walls secured to the ends of the casing, said closure walls being respectively provided with gas passage tubes forming gas inlet and outlet means, a third gas passage tube in said casing in transverse overlapping relation with said inlet and outlet tubes, partition walls in said casing, one of said tubes being disposed with its axis offset from a plane passing through the axes of the other tubes, tubular baffle means having convergently arranged walls isolating a region of the offset tube and extending between and secured to diametrically opposed portions of the tubular casing, the wall region of the isolated portion of the tube being formed with a plurality of small openings providing acoustic couplings between the tube and the region defined by the tubular baffle means, said partition walls and at least one of said end closure walls forming two longitudinally spaced transverse gas passage means providing for transverse flow of gases from an end of one tube to an end of another tube, one of the walls of said transverse passage means being imperforate and arranged whereby low frequency sound waves entrained in the gas stream and moving lengthwise of the gas passage tubes are impinged upon the imperforate wall and reverberated through the tubes and attenuated by wave interference.

4. A sound attenuating means for use with a gas stream including, in combination, a tubular shell casing of oval cross-section, closure walls secured to the ends of the casing, said closure walls being respectively provided with gas passage tubes forming gas inlet and outlet means, a third gas passage tube in said shell in transverse overlapping relation with said inlet and outlet tubes, intermediate walls in said shell, one of said tubes being disposed with its axis offset from a plane passing through the axes of the other tubes, an intermediate tubular shell of pear-shaped cross-section surrounding the offset tube at its region of transverse overlap with another of said tubes and extending between and secured to diametrically opposed portions of the tubular shell casing, the wall of the tube surrounded by the intermediate shell being formed with a plurality of small apertures forming acoustic couplings between the said tube and the interior of the intermediate shell, transverse gas passage means formed by at least one of the closure walls and intermediate walls providing for transverse flow of gases from an end of one tube to an end of another tube, the walls of said

transverse passage means being arranged whereby sound waves entrained in the gas stream and moving lengthwise of the gas passage tubes impinge upon the walls and are reverberated through the tubes to attenuate sound waves by interference, a plurality of high frequency resonating chambers, a plurality of small apertures in one of said gas passage tubes forming acoustic couplings with the high frequency resonating chambers, said intermediate walls, chambers and gas passage means being arranged whereby the gases of the stream circulate throughout the entire interior regions of the tubular shell

casing to establish substantially uniform temperatures throughout the interior of said tubular shell casing.

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