Oct. 8, 1968 G. R. CROUSE 3,404,445

METHOD OF FORMING A SOUND ATTENUATING AND GAS PASSAGE TUBE CONSTRUCTION

Original Filed Sept. 14, 1964 2 Sheets-Sheet 1

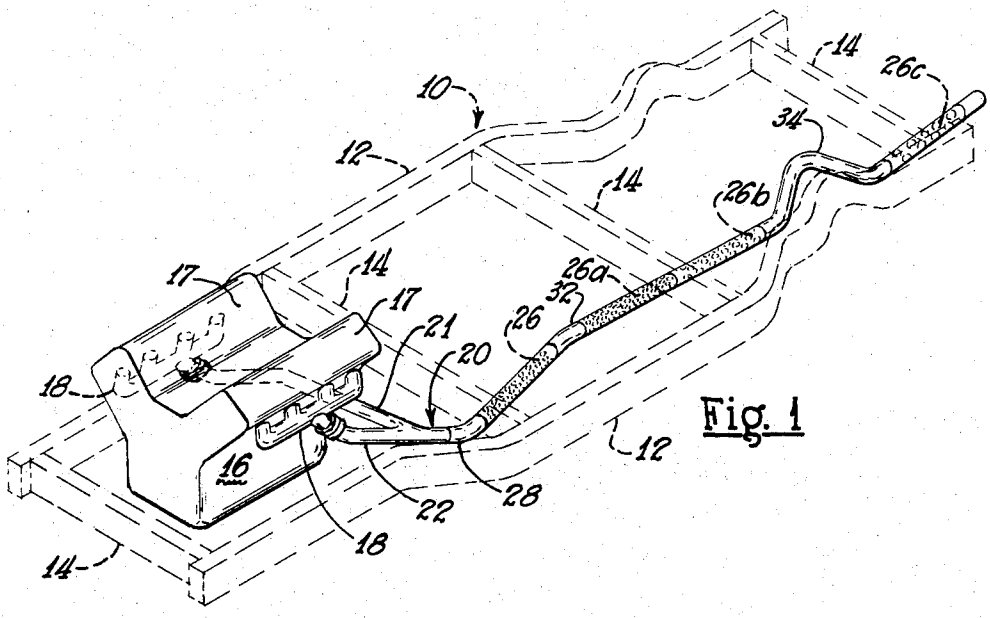


Fig. 1

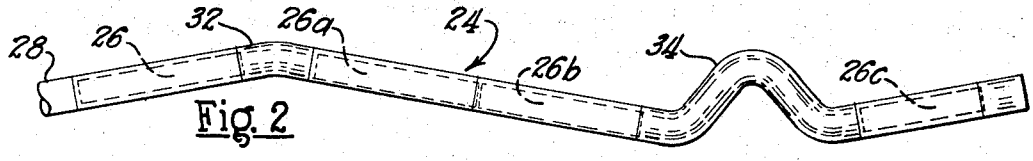


Fig. 2

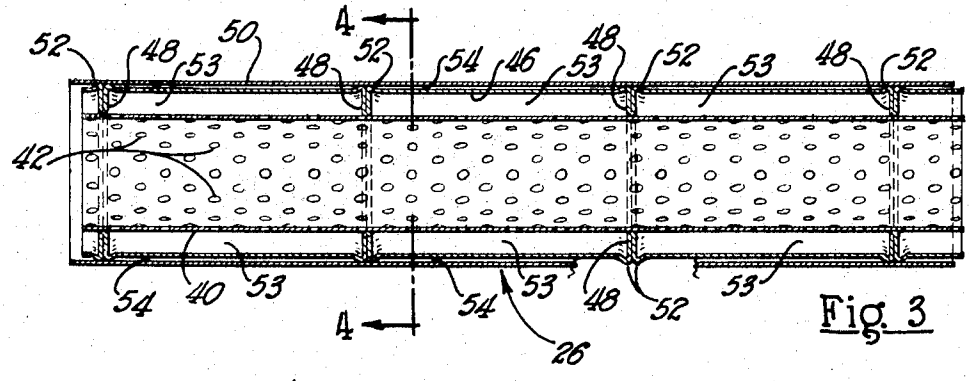


Fig. 3

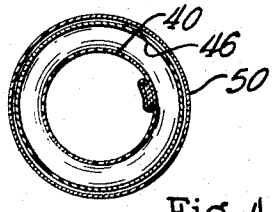


Fig. 4

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METHOD OF FORMING A SOUND ATTENUATING AND GAS PASSAGE TUBE CONSTRUCTION

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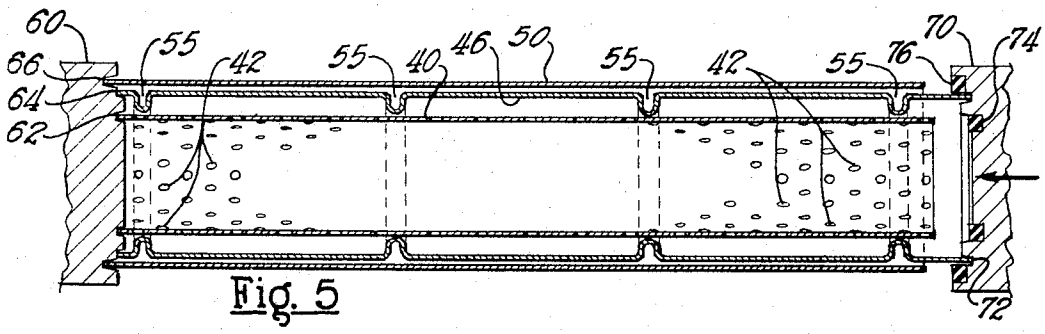


Fig. 5

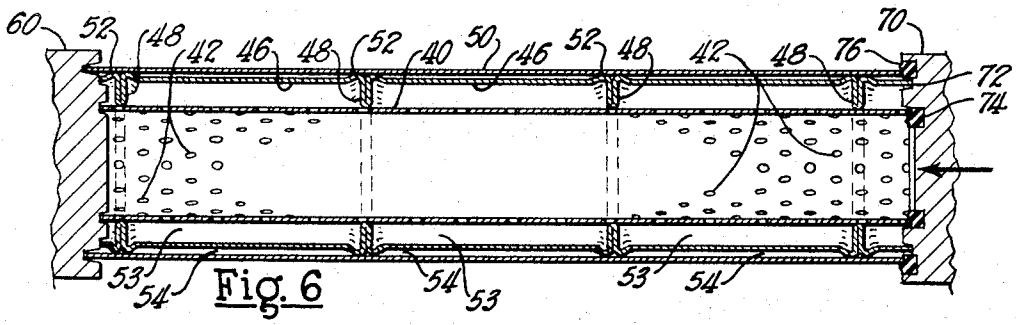


Fig. 6

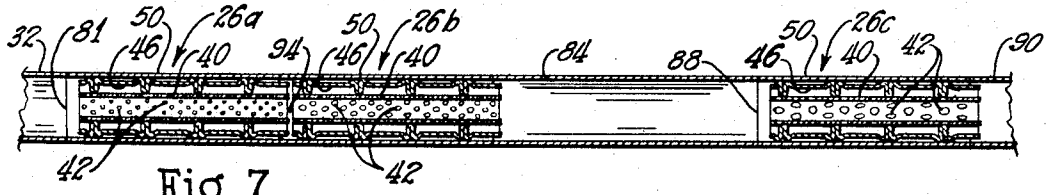


Fig. 7

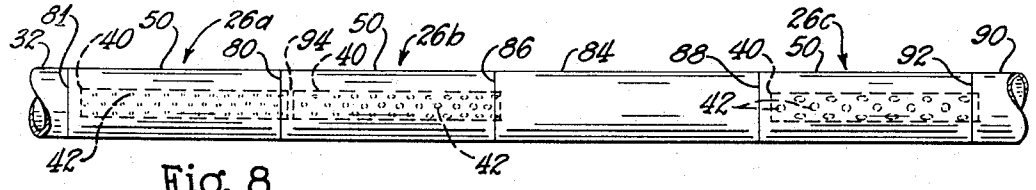


Fig. 8

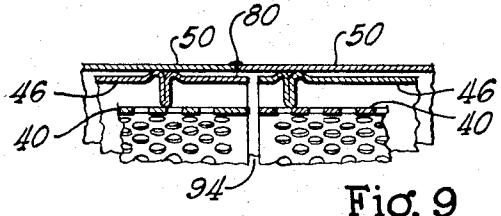


Fig. 9

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3,404,445

METHOD OF FORMING A SOUND ATTENUATING AND GAS PASSAGE TUBE CONSTRUCTION

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Original application Sept. 14, 1964, Ser. No. 396,247, now Patent No. 3,276,540, dated Oct. 4, 1966. Divided and this application May 23, 1966, Ser. No. 552,059

9 Claims. (Cl. 29—157)

This is a division of my copending application Ser. No. 396,247 filed Sept. 14, 1964, now Patent No. 3,276,540.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

The exhaust conveying and sound attenuating arrangement of the invention comprises a plurality of gas-conveying and sound attenuating units, each contained within an outer shell or enclosure and the outer shells or enclosures welded or otherwise coupled together in end-to-end

realtion or with coupling tubes to form a continuous exhaust gas conveying tube or tubular construction.

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

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

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

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

The friction set up in the method of assembly between the distorted portions forming the partitions **48** and the gas passage tube **40** and between the outwardly distorted ridges **52** and the outer tube or shell **50** securely retains or holds these components of each attenuating unit in proper relation without extraneous fastening means. The annular spaces **53** between the gas passage tube **40** and the shell **46** and defined lengthwise by the partitions **48** provide sound attenuating chambers acoustically coupled with the interior of the gas passage tube **40** by the openings **42**.

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

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

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

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

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

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

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

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

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

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

shape similar to that shown in FIGURE 1 for conveying exhaust gases from the engine exhaust manifold for discharge into the air through the tailpipe **90**.

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

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

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

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

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

I claim:

1. The method of forming a multiple tube assembly including the steps of distorting metal of the wall of a first tube inwardly at lengthwise spaced regions, telescoping the first tube between second and third tubes of diameters whereby the first tube is spaced from the second and third tubes, and impressing pressure lengthwise on the first tube to force the metal at the lengthwise spaced regions into engagement with the second tube and the third tube for securing the tubes in assembled relation with annular regions between the first and second tubes and between the first and third tubes, the distorted metal providing partitions subdividing the annular spaces into lengthwise arranged individual chambers.

2. The method of forming a multiple tube assembly including the steps of distorting metal of the wall of a first tube at lengthwise spaced regions to form circular grooves therein, telescoping the first tube having the circular grooves between second and third tubes of diameters whereby the first tube is concentric with and spaced from the second and third tubes, and impressing pressure lengthwise on the first tube to concomitantly force one region of the metal defining the grooves inwardly into engagement with the second tube and another region of the metal outwardly into engagement with the third tube for securing the tubes in assembled relation with annular regions between the first and second tubes and between the first and third tubes and whereby the distorted metal forms partitions subdividing the annular regions into lengthwise arranged individual chambers.

3. The method of forming a telescoped tube assembly including the steps of distorting metal of the wall of a first tube to form longitudinally spaced inwardly extending circular grooves, disposing a second tube of lesser diameter having a perforated wall region within the first tube with the tubes in concentric relation, telescoping an imperforate walled third tube over the first tube and in concentric relation with and spaced laterally from the first tube to provide annular regions between the first and second tube and between the first and third tubes, and impressing pressure lengthwise on the first tube to concomitantly force a portion of the metal adjacent the grooves inwardly into engagement with the perforated tube and another portion of the metal outwardly into engagement with the third tube for securing the tubes in assembled relation and thereby forming lengthwise arranged annular chambers between the first tube and the second and third tubes.

4. The method of forming telescoped tube constructions and connecting the tube constructions including the steps of distorting metal of the wall of a first tube to form longitudinally spaced, inwardly extended circular grooves, disposing a second tube of lesser diameter having a perforated wall region within the first tube with the tubes in concentric relation, telescoping a third tube having imperforate walls over the first tube and in concentric relation with and spaced from the first tube to providing an annular region between the first and second tubes, impressing pressure lengthwise on the perforated tube to concomitantly force a portion of the metal adjacent the grooves inwardly into engagement with the perforated tube and another portion of the metal outwardly into engagement with the third tube for securing the tubes in assembled relation and forming lengthwise arranged annular spaces between the first tube and the second and third tubes and the annular spaces subdivided into chambers by the distorted metal of the first tube, said first and second tubes being of lesser length than the third tube, disposing two of the telescoped tube constructions with the third tubes of each in end-to-end relation and connecting the third tubes to form a continuous imperforate pipe.

5. The method of forming a gas conveying duct enclosing tubular sound attenuating constructions including the steps of distorting metal of the wall of a first tube to form longitudinally spaced inwardly extending circular grooves, disposing a second tube of lesser diameter having a perforated wall region within the first tube with the tubes in concentric relation forming an annular region between the first and second tube, telescoping a third tube having imperforate walls over the first tube and in concentric relation with and spaced from the first tube to provide an annular region between the first and third tube, impressing pressure lengthwise on the perforated tube to concomitantly force the metal adjacent the grooves into engagement with the second and third tubes for securing the tubes in assembled relation and subdividing the annular spaces between the first tube and the second and third tubes by the distorted metal of the first tube into lengthwise arranged individual chambers, said first and second tube constituting a sound attenuating construction, disposing two of the sound attenuating constructions with the third tubes in abutting end-to-end relation, and welding the abutting regions to form a continuous imperforate gas conveying duct.

6. The method of forming and joining telescoped tube assemblies including the steps of distorting metal of the wall of a first tube to form longitudinally spaced inwardly extending circular grooves, disposing a second tube of lesser diameter having a perforated wall region within the first tube with the tubes in concentric spaced relation, telescoping a third tube having imperforate walls over the first tube and in concentric relation with and spaced from the first tube, impressing pressure lengthwise on the first tube to concomitantly force the metal adjacent the grooves into engagement with the first tube and with the third tube for securing the tubes in assembled relation and forming lengthwise arranged annular spaces between the first tube and the second and third tubes and separated by the distorted metal of the first tube into individual chambers, said first and second tubes in assembly being of lesser length than the third tube, disposing two of the telescoped tube assemblies with the third tubes of each in abutting end-to-end relation, and welding the abutting regions to form a continuous imperforate wall with the adjacent end regions of the first and second tubes of the telescoped tube assemblies in spaced relation.

7. A method of forming a sound attenuating and gas passage tube construction for use with the exhaust gas stream of an internal combustion engine of an automotive

vehicle including the steps of pre-assembling an inner perforated gas passage tube within and spaced transversely from an intermediate tube of larger diameter, said intermediate tube having annular grooves formed therein at spaced regions, telescoping an outer tube of a diameter larger than the intermediate tube and having an imperforate wall over the intermediate tube in concentric relation with the intermediate tube, exerting pressure lengthwise on the intermediate tube to distort lengthwise spaced regions of the intermediate tube laterally into engagement with the inner gas passage tube and into engagement with the outer tube to secure the tubes in spaced relation.

8. A method of forming a sound attenuating and gas passage tube construction for use with the exhaust gas stream of an internal combustion engine of an automotive vehicle including the steps of forming a telescope tubular assembly by pre-assembling an inner perforated gas passage tube within and spaced transversely from an intermediate tube of larger diameter, said intermediate tube having annular grooves formed therein at spaced regions, telescoping an outer tube of a diameter larger than the intermediate tube and having an imperforate wall over the intermediate tube in concentric relation with the intermediate tube, exerting pressure lengthwise of the intermediate tube to distort lengthwise spaced regions of the intermediate tube laterally into engagement with the inner gas passage tube and into engagement with the outer tube to secure the tubes in spaced relation, abutting the adjacent ends of outer tubes of two of said telescoped assemblies, and welding the abutting regions of the outer tubes together circumferentially to form a gas tight seal.

9. A method of forming a sound attenuating and gas passage tube construction for use with the exhaust gas

stream of an internal combustion engine of an automotive vehicle including the steps of forming a telescoped tube unit by pre-assembling an inner perforated gas passage tube within and spaced transversely from an intermediate tube of larger diameter, said intermediate tube having annular grooves formed therein at spaced regions, telescoping an outer tube of a diameter larger than the intermediate tube and having an imperforate wall over the intermediate tube in concentric but in spaced transverse relation with the intermediate tube, exerting pressure lengthwise of the intermediate tube to distort lengthwise spaced regions of the intermediate tube laterally into engagement with the inner gas passage tube and into engagement with the outer tube to secure the tubes in spaced relation, abutting the adjacent ends of outer tubes of two of said telescoped tube units, welding the abutting regions of the outer tubes together circumferentially to form a gas tight seal, disposing an end of a plain tube in engagement with an end of one of said telescoped tube units, and welding the engaging regions of the outer tube of the adjacent telescoped tube unit to the end of the plain tube to form a sealed joint.

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