Aug. 13, 1968 J. R. HALL 3,396,813

SILENCER OR MUFFLER AND METHOD OF PRODUCING SAME

Filed April 26, 1967 4 Sheets-Sheet 1

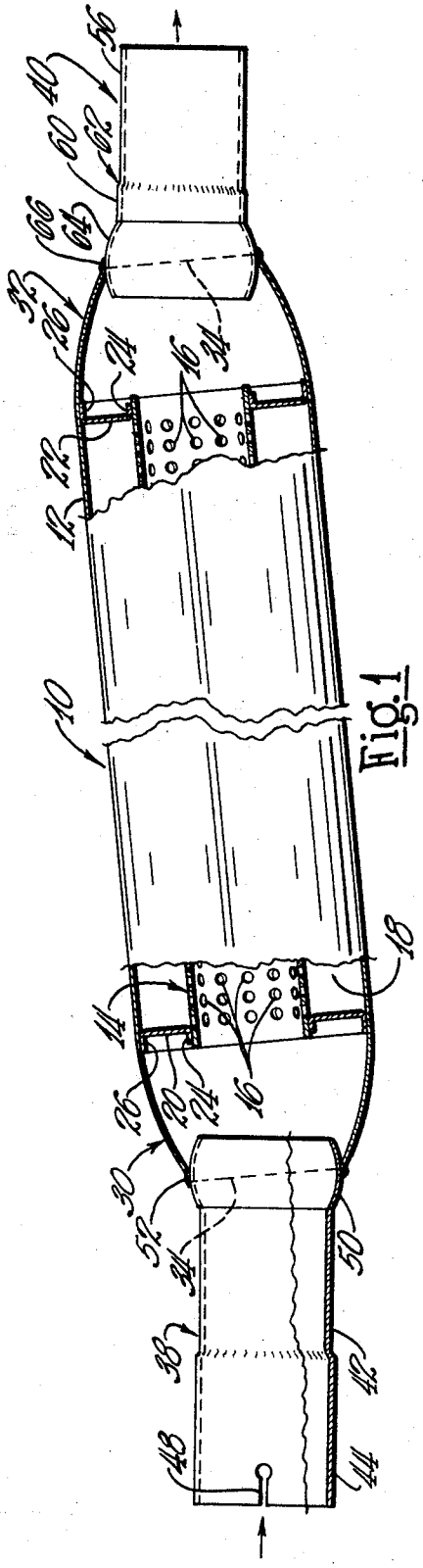

Fig. 1

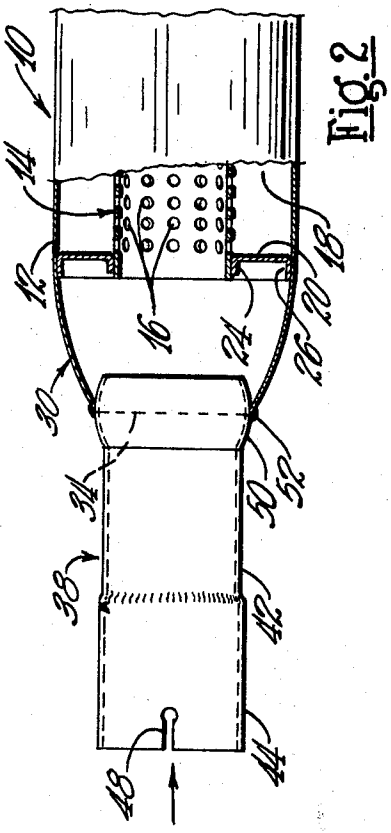

Fig. 2

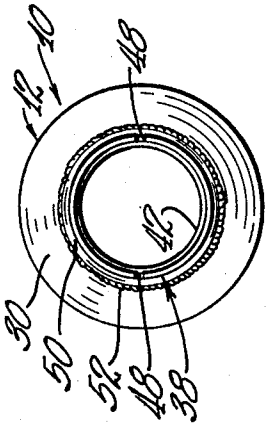

Fig. 3

INVENTOR.
JAMES R. HALL
BY
Harry O. Ernsberger
ATTORNEY

Aug. 13, 1968 J. R. HALL 3,396,813

SILENCER OR MUFFLER AND METHOD OF PRODUCING SAME

Filed April 26, 1967 4 Sheets-Sheet 2

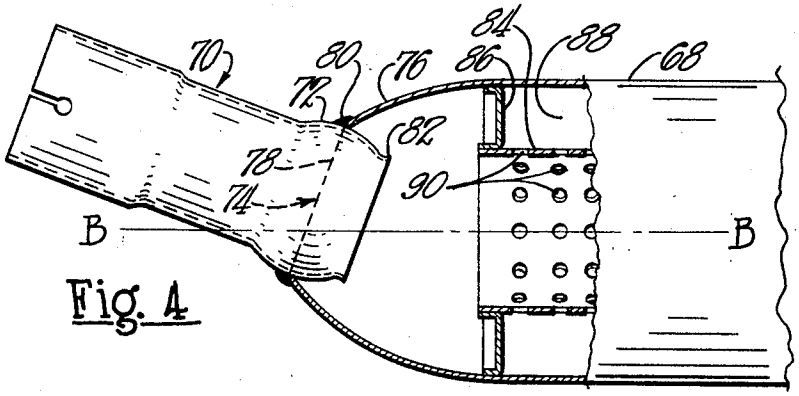

Fig. 4

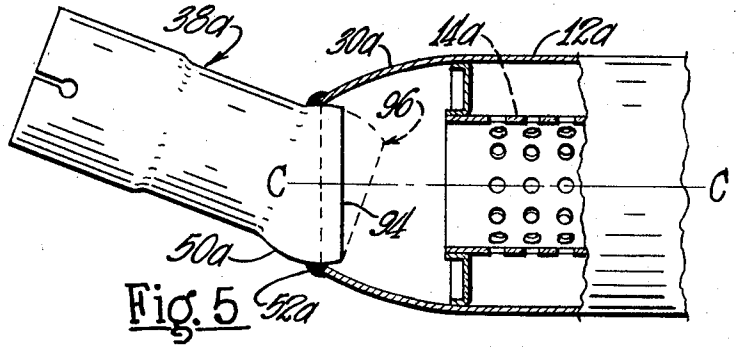

Fig. 5

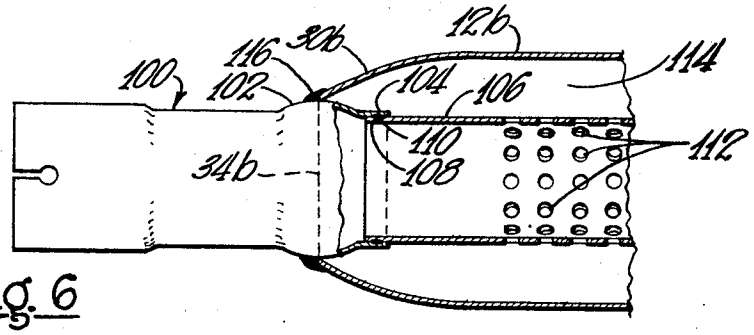

Fig. 6

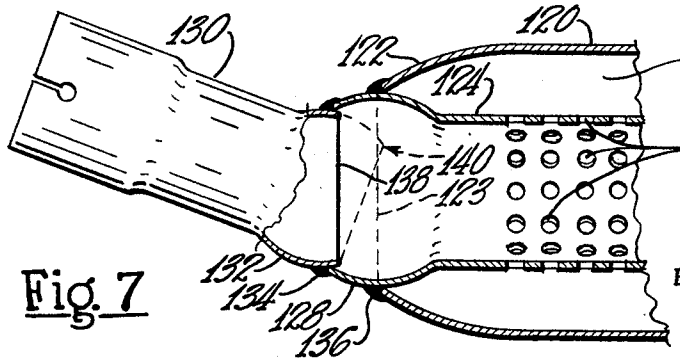

Fig. 7

INVENTOR.
JAMES R. HALL
BY
Harry O. Ernsberger
ATTORNEY

SILENCER OR MUFFLER AND METHOD OF PRODUCING SAME

Filed April 26, 1967 4 Sheets-Sheet 3

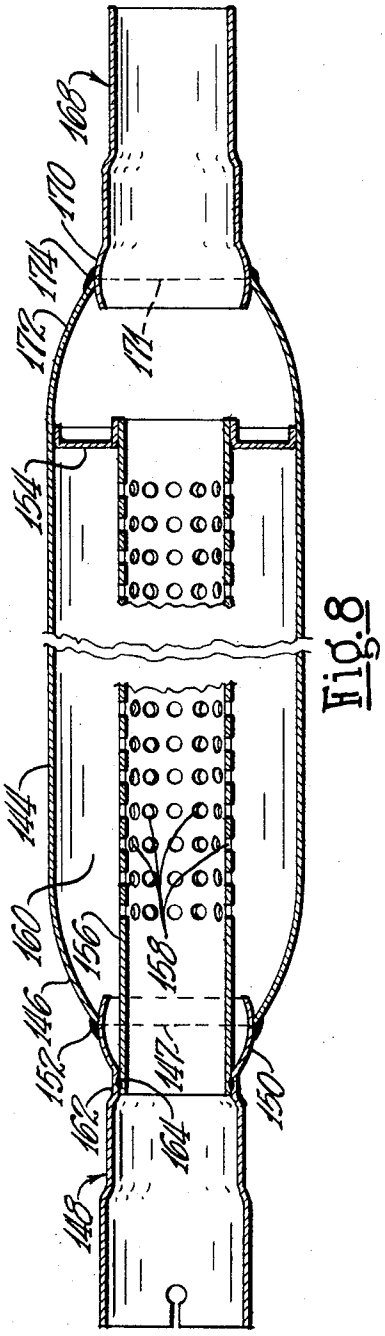

Fig. 8

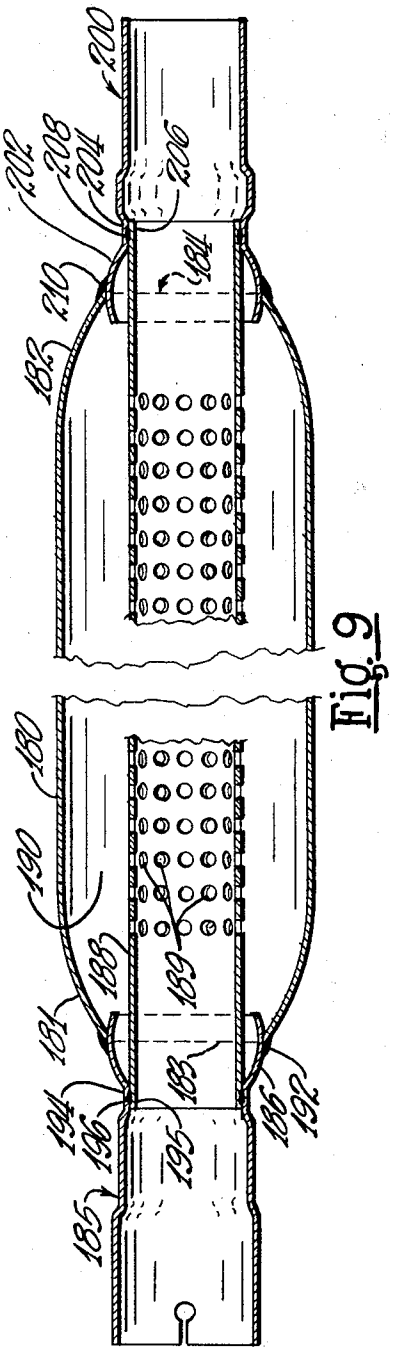

Fig. 9

INVENTOR.
JAMES R. HALL
BY
Harry O. Ernsberger
ATTORNEY

Aug. 13, 1968 J. R. HALL 3,396,813

SILENCER OR MUFFLER AND METHOD OF PRODUCING SAME

Filed April 26, 1967 4 Sheets-Sheet 4

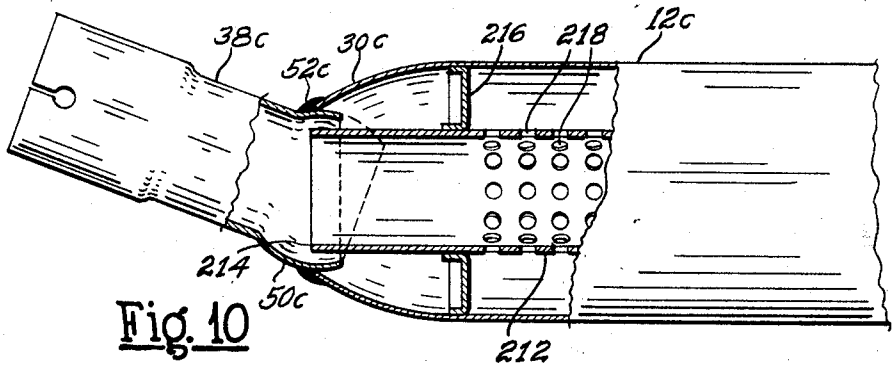

Fig. 10

INVENTOR.
JAMES R. HALL
BY
Harry O. Ernsberger
ATTORNEY

United States Patent Office 3,396,813 Patented Aug. 13, 1968

3,396,813

SILENCER OR MUFFLER AND METHOD OF PRODUCING SAME

James R. Hall, Toledo, Ohio, assignor to Oldberg Manufacturing Company, Grand Haven, Mich., a corporation of Michigan

Filed Apr. 26, 1967, Ser. No. 633,900
16 Claims. (Cl. 181—61)

ABSTRACT OF THE DISCLOSURE

This invention relates to sound attenuation devices and more particularly to a silencer or muffler and a method of producing same for attenuating sound waves of exhaust gas streams from an internal combustion engine of an automotive vehicle and embraces a one-piece tubular muffler shell with dome-shaped smoothly curved end regions in combination with coupling bushings or nipples having spherically-shaped regions fitting into openings at the ends of the muffler and being adjustable to varying angularities, the spherical regions of the bushings or nipples being welded to the ends of the muffler shell.

The present invention relates to silencers or mufflers and method of producing same, the silencers or mufflers being particularly adapted for attenuating sound waves of exhaust gas streams from internal combustion engines of automotive vehicles. Sound attenuating muffler constructions have heretofore been fashioned with tubular outer shells with ends or end headers secured to the shells and bushings inserted in openings in the end headers and secured by welding or other suitable means.

In such constructions the bushings were necessarily disposed on an axis coincident or parallel with the longitudinal axis of the shell. The chassis of an automotive vehicle with which the muffler may be used usually embodies several reinforcement or structural members and the engine exhaust conveying system including the sound attenuating device or muffler must be fashioned to avoid interference with components of the chassis construction. With prior muffler constructions wherein the bushings were aligned or parallel with the axis of the muffler, many installations required special angularly-arranged end regions of the exhaust pipe and tailpipe requiring special bending of the exhaust pipe and tailpipe to accommodate a muffler or silencer. Such arrangements are costly and necessitate extensive fabricating operations.

The present invention embraces the provision of a silencer or muffler construction embodying a tubular outer shell of one-piece construction fashioned with smoothly curved dome-shaped end regions of progressively reducing diameter, the terminals of the end regions defining circular openings to accommodate spherically-shaped regions of coupling members or bushings welded to the reduced end regions of the muffler shell.

The invention embraces a method of fabricating a muffler involving progressively reducing an end region of a tubular shell to define a circular opening at the terminus of the reduced region, fitting a spherically-shaped portion of a coupling member into the opening, adjusting the angular position of the member relative to the shell, and welding the reduced end of the muffler to the spherically-shaped portion of the fitting.

Another object of the invention is the provision of a muffler construction embodying a one-piece muffler shell having dome-shaped end portions or sections terminating in circular openings arranged to accommodate gas inlet and outlet coupling members or bushings having ball-shaped portions extending into the openings wherein one or both bushings provide support means for tubular gas passage means disposed in the muffler shell and fashioned with perforations forming acoustic or sound attenuating couplings with the surrounding chamber for attenuating sound waves.

Another object of the invention resides in a one-piece muffler shell construction having curved end regions of progressively reduced diameter, each end region terminating in a circular edge defining an opening to receive a member having a ball-shaped configuration wherein a seal is effected by welding the circular terminal edge of the muffler to the ball-shaped configuration of the member throughout the circumferential region of engagement.

Another object of the invention resides in a one-piece muffler shell having an end section of progressively decreasing diameter terminating in a circular edge defining an opening, the opening adapted to accommodate a spherically-shaped portion of a coupling element adjustable to a desired angle and the element welded to the end region of the shell throughout the circular edge region.

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 side elevational view, partly in section, of one form of muffler construction illustrating coupling members in angularly-arranged positions with respect to the muffler shell;

FIGURE 2 is an elevational view, partly in section, of a portion of the muffler construction shown in FIGURE 1 with a coupling member in axially aligned relation with the muffler axis;

FIGURE 3 is an end elevational view of the arrangement shown in FIGURE 2;

FIGURE 4 is an elevational view showing a portion of a muffler construction illustrating a coupling member angularly arranged with respect to the longitudinal axis of the muffler;

FIGURE 5 is an elevational view, partly in section, of a portion of a muffler similar to FIGURE 2 illustrating a modified form of coupling member in angularly-arranged position relative to the muffler shell;

FIGURE 6 is a longitudinal sectional view of a portion of a muffler shell and coupling member assembly wherein the coupling member provides support for a gas passage tube;

FIGURE 7 is a fragmentary sectional view of a muffler construction embodying a gas passage tube having a portion disposed in an end opening and welded to the muffler shell and a coupling member secured to an extremity of the gas passage tube;

FIGURE 8 is a longitudinal sectional view of a muffler construction illustrating a coupling member arranged to provide support for one end of a gas passage tube;

FIGURE 9 is a longitudinal sectional view of a form of muffler construction wherein the couplings support a perforated gas passage tube, and

FIGURE 10 is a longitudinal sectional view of a portion of a muffler shell and coupling member assembly illustrating the gas passage tube extending into the coupling member.

Referring to the drawings in detail and initially to the construction shown in FIGURES 1 through 3, the sound attenuating or muffler construction **10** is inclusive of an outer shell **12** of one piece of metal fashioned of generally cylindrical tubular shape in which is disposed a cylindrically-shaped gas passage tube **14** of lesser diameter than the shell **12** and having a comparatively large number of openings **16** which form acoustic couplings

with the elongated annular sound attenuating chamber 18 between the gas passage tube 14 and the shell 12.

In the form shown in FIGURES 1 and 2, spaced partitions 20 and 22 of annular shape are disposed in spaced relation lengthwise of the shell 12. Each of the partitions is fashioned with an inner flange 24 defining an opening in which is snugly fitted the gas passage tube 14 which may, if desired, be welded to one or both of the flanges. Each partition is provided with a peripheral flange 26 which is snugly fitted into the interior of the shell 12.

As illustrated in FIGURES 1 and 2, the end regions are of dome shape and in the method of fabrication the assembly of gas passage tube and partitions 20 and 22 is disposed within the cylindrical tubular shell 12 before the end regions thereof are reduced in dimension to dome-shaped configuration.

A feature of the invention is the provision of a one-piece muffler shell 12 which is of tubular shape and cylindrical throughout its length prior to the reduction in dimension of its end regions. The shell 12 is of sheet metal of the seamless tube type or a tube of the welded seam type. As shown in FIGURE 1, the end sections or regions 30 and 32 are configurated with an inward taper but each end region is smoothly curved and of gradually decreasing diameter from the cylinder portion to the end or terminus 34 to form a dome shape.

The curved end sections or regions 30 and 32 of the shell may be swaged to dome shape by means of swaging dies, or the metal at these sections may be spun inwardly to the configuration illustrated in the drawings. The curved end sections or rounded end regions of the shell may be fashioned by utilizing a tube of smaller diameter for the shell and expanding the tube to a larger diameter with rounded or dome-shaped end regions. This may be accomplished by employing a cavity mold or die shaped to the exterior configuration of the muffler shell and expanding the tube wall outwardly by polyurethane forming. The terminus of each end section is a circular edge defining a circular opening, the circular or terminal edge 34 of the opening lying in a plane normal to the longitudinal axis of the tubular shell 12. By reason of the swaging or spinning operations in progressively reducing the end regions or sections of the muffler shell to a dome shape, the metal may be progressively thickened slightly.

The invention embraces the provision of a nipple, bushing or coupling for each end of the muffler shell joined to the terminus of the reduced end portions of the muffler shell. The couplings or bushings 38 and 40 for the ends of the muffler shell are of generally similar construction. As shown in FIGURES 1 and 2, the bushing 38 is of a character for use at the gas inlet end of the muffler and comprises a generally tubular-shaped member of circular cross section having a central or intermediate portion 42 which is integrally joined with an adjacent cylindrical end region 44 of slightly larger internal diameter than the portion 42 to receive the end region of an exhaust pipe or exhaust conveying tube connected with the exhaust system of an internal combustion engine.

The exhaust pipe (not shown) is telescoped into the cylindrical portion 44 and a clamp means (not shown) of conventional construction surrounds the portion 44 near its end region. The wall of the portion 44 near the end thereof is provided with a plurality of slots 48 to enable the clamp to draw the end regions of the portion 44 into tight engagement with an exhaust pipe. The coupling or bushing 38 is fashioned at its opposite end with a spherically-shaped portion 50 of a diameter to be snugly received within the circular opening defined by the terminal region of the reduced portion 30 of the muffler shell.

As the exterior configuration of the portion 50 is spherical or ball shaped, the coupling member 38 may be adjusted to various angular positions with respect to the longitudinal axis of the muffler shell 12.

As shown in FIGURE 1, both the inlet and outlet couplings or bushings 38 and 40 are angularly-arranged with respect to the longitudinal axis of the shell 12. The circular terminal edge 34 defining the opening in the dome-shaped portion 30 of the muffler shell is welded as at 52 in a circular path throughout the circumference of the ball shape portion 50 to provide a gas tight seal between the muffler shell 12 and the coupling 38, the welding further serving to maintain the predetermined angular relationship of the coupling 38 with respect to the shell.

The coupling or bushing 40 at the gas outlet end of the muffler is fashioned with a cylindrical portion 56, and a tailpipe (not shown) may be telescoped over the exterior of the cylindrical portion 56 and conventional clamp means may be provided embracing the tailpipe to draw the latter into a snug engagement with the portion 56. Adjacent the portion 56 is a cylindrical region 60 of a diameter slightly larger than the portion 56 providing an abutment or shoulder 62 to limit the lengthwise position of the tailpipe telescoped over the portion 56. The coupling or bushing 40 is fashioned with a spherically-shaped portion 64 of a diameter to be snugly received within the circular terminal edge region 34 of the curved portion 32 of the muffler.

FIGURES 2 and 3 illustrate a portion of the muffler 10 and the inlet coupling or fitting 38 showing the axis of the coupling aligned with the axis of the muffler. It is to be understood that the outlet coupling 40 may likewise be arranged whereby its longitudinal axis is aligned with the axis of the muffler 10 in the same manner.

As particularly shown in FIGURE 1, the curved end regions or dome-shaped regions 30 and 32 of the muffler shell 12 are smoothly curved and progressively reduced in diameter toward the circular terminal edges 34, the edges defining circular openings in the ends of the shell. The circular edge regions 34 snugly receive the ball-shaped configurations 50 and 64 of the respective couplings 38 and 40 and the edges 34 are welded to the peripheries of the ball-shaped configurations of the couplings by the circular welds 52 and 66 coincident with the edges 34. The curved or dome-shaped portions 30 and 32 of the muffler shell are preferably of a configuration as illustrated in FIGURE 1 but it is to be understood that the particular shape of curvature may be varied or modified dependent upon the length of space desired between the headers or partitions 20 and 22 and the end couplings 38 and 40, the diameter of the muffler shell, and the diameters of the couplings or bushings 38 and 40.

An important feature of the construction is that each curved portion 30 and 32 terminates in a circular edge 34 so that when the edge regions are welded to the couplings as at 52 and 66, the welds will be circular as they are coincident with the edges. These structural features facilitate forming the circular welds by production methods and assures a gas tight seal between the ball or spherically-shaped portion of each coupling with the curved portions 30 and 32 at the ends of the shell. It will be apparent that the couplings 38 and 40 may be arranged in various angular positions but each of the welds 52 and 66 will be of circular contour irrespective of the angularities of the couplings with the muffler shell.

FIGURE 4 illustrates a modified configuration for the curved end region of a muffler shell 68. In this form of construction, the gas inlet coupling or fitting 70 is fashioned with a ball-shaped or spherically-shaped configuration 72, the center 74 of generation of the ball-shaped portion 72 being displaced laterally from the longitudinal axis B—B of the muffler 68. The curved or dome-shaped portion 76 at the end region of the muffler shell 68 is fashioned to terminate in a circular edge 78 defining an opening of a dimension to snugly receive the spherically-shaped exterior configuration 72 of the tubular coupling 70. The circular terminal edge 78 of the curved portion 76 of the muffler shell is welded as at

80 to the ball-shaped portion 72 throughout its circumference to provide a circular weld.

In the arrangement shown in FIGURE 4, the coupling or fitting 70 may be angularly-arranged with respect to the muffler shell 68 and displaced from the axis of the muffler shell to accommodate particular installations of the muffler with an exhaust system of an internal combustion engine of an automotive vehicle. The outlet or opening of the coupling 70 within the muffler shell may be defined by an outwardly flared terminus or flange 82 to facilitate exhaust gas flow into the muffler shell with a minimum of whistling noise.

Disposed in the muffler shell 68 is a gas passage tube 84 supported by a partition or header 86, the gas passage tube being fashioned with a large number of small perforations or openings 90 providing acoustic couplings between the gas passage tube and the annular sound attenuating chamber 88 surrounding the tube.

It is to be understood that the muffler 68 may be fashioned at its opposite end to accommodate an outlet coupling secured to a similarly curved portion of the shell in the same manner as the inlet coupling 70.

FIGURE 5 illustrates a gas inlet coupling 38*a* having a ball-shaped portion 50*a* secured by welding 52*a* to the circular terminal edge of a curved or dome-shaped portion 30*a* of a muffler shell 12*a*. In this form the ball configuration 50*a* terminates in a circular edge 94 lying in a plane substantially normal to the longitudinal axis C—C of the muffler shell 12*a*. The coupling or fitting 38*a* is similar to the fitting 38, shown in FIGURE 1, but with the portion 96, indicated in broken lines, removed from the portion of the fitting extending into the muffler shell 12*a*.

Through this arrangement the exhaust gas delivered from the opening defined by the circular edge 93 is more nearly directed axially of the muffler shell 12*a* toward the gas passage tube 14*a*. With the arrangement shown in FIGURE 5 the resistance of deflecting the exhaust gases toward the gas passage tube 14*a* is minimized. The fitting 38*a* is adapted to accommodate an exhaust pipe (not shown) for conveying exhaust gases into the muffler. It is to be understood that an outlet fitting of the same character as illustrated at 38*a* may be secured to a curved portion at the other end of the muffler shell 12*a*.

FIGURE 6 illustrates a modified form of the invention wherein a gas conveying coupling provides support for a gas passage tube. The muffler shell 12*b* is provided with a curved or dome-shaped portion 30*b* terminating in a circular terminal edge 34*b* defining an opening.

A tubular coupling or bushing fitting 100 is fashioned with a sperically-shaped or ball portion 102 which snugly fits in the opening defined by the circular edge 34*b* of the curved end region 30*b* of the muffler shell. The spherically-shaped or ball-shaped portion 102 is fashioned with a cylindrical extension 104 disposed within the muffler shell 12*b*.

A gas passage tube 106, disposed in the shell 12*b*, has an end region 108 in telescoping or overlapping relation with the cylindrical portion 104 of the coupling or bushing 100. The overlapping portions of the coupling and gas passage tube may be welded together as shown at 110. The gas passage tube 106 has a large number of small openings 112 which form acoustic couplings with the annular chamber 114 surrounding the gas passage tube for attenuating sound waves. Through engagement of the end of the gas passage tube with an extension of the coupling 100, one end of the gas passage tube is supported by the coupling or bushing 100.

The other end of the gas passage tube 106 may be supported by a partition, such as a partition of the character illustrated at 22 in the form of the invention illustrated in FIGURE 1. In assembling the arrangement shown in FIGURE 6, the gas passage tube 106 is welded to the extension 104 of the coupling or bushing prior to its assembly within the muffler shell 12*b*. In this form, the axes of the coupling 100 and the gas passage tube 106 are in aligned relation.

Upon positioning of the ball-shaped portion 102 in the circular opening defined by the circular edge 34*b* of the muffler shell, the terminal edge 34*b* of the muffler shell 12*b* is welded as at 116 throughout the circumference of the exterior surface of the spherically-shaped portion 102 of the coupling 100 to form a gas tight joint between the coupling and the muffler shell. The coupling 100 is adapted to accommodate the end region of a conventional exhaust pipe for conveying exhaust gases into the muffler. A coupling similar to the coupling 100 may be mounted in the outlet region of the muffler shell and the gas passage tube supported thereby in the manner illustrated in FIGURE 6.

FIGURE 7 illustrates another form of the invention. In this form an end region of the muffler shell 120 is fashioned with a curved or dome-shaped portion 122 terminating in a circular opening defined by a circular edge 123. Disposed within the muffler shell 120 is a cylindrically-shaped gas passage tube 124 having a large number of small openings 125 which form acoustic couplings with an annular chamber 126 surrounding the gas passage tube. An end of the gas passage tube is provided with a spherically-shaped or ball-shaped portion 128 which snugly fits within the circular opening defined by the circular edge 123 at the end of the muffler shell 120.

The spherically-shaped portion 128 terminates in a circular opening. A tubular coupling or bushing 130 is fashioned with a spherically-shaped or ball-like portion 132, the exterior diameter being of a dimension to snugly fit the circular opening defined by the terminal edge of the curved or ball-shaped portion 128 of the gas passage tube.

The circular terminal edge of the ball-shaped portion 128 is welded as at 134 to the ball shaped portion 132 of the coupling throughout its periphery. The terminal edge 123 of the dome-shaped portion 122 of the muffler shell 120 is welded as at 136 to the ball-shaped portion 128 throughout its periphery.

The circular weldings 134 and 136 provide gas tight or sealed joints between the coupling 130 and the gas passage tube, and between the gas passage tube and the end region of the muffler shell 120. The coupling 130 may be angularly adjusted with respect to the axis of the gas passage tube 124 as desired and welded in adjusted position. In order to enhance the flow of exhaust gases from the coupling 130 into the gas passage tube, the end of the coupling within the ball-shaped portion 128 of the gas passage tube may be terminated in a circular edge 138 normal to the axis of the gas passage tube as illustrated in the drawings.

The portion 140 of the ball-shaped configuration 132 on the coupling or bushing, illustrated by broken lines, may be removed to facilitate diversion of the gases flowing through the coupling 130 toward the gas passage tube 124 with a minimum of flow resistance. In the form of the invention shown in FIGURE 7, an end of the gas passage tube is supported by an end region of the muffler shell 120, and the angularly disposed coupling or bushing 130, welded to a ball-shaped portion of the gas passage tube, is thus supported by the gas passage tube.

FIGURE 8 shows a further modification of the invention. In this form the muffler shell 144 is fashioned with a curved or dome-shaped end portion 146 terminating in a circular edge 147 defining a circular opening at the terminus of the dome-shaped portion 146. A gas inlet coupling or bushing 148 is fashioned with a spherically-shaped or ball-like portion 150 which snugly fits into the circular opening defined by the terminal edge 147, the terminal edge of the dome-shaped portion 146 of the muffler shell being welded as at 152 throughout the periphery of the ball-shaped portion 150 to provide a gas tight joint between the coupling 148 and the muffler shell 144.

Disposed within the muffler shell 144 is a header or partition 154 which supports one end of a cylindrical gas pas-

sage tube **156**, the latter being fashioned with a large number of small openings **158** which form acoustic couplings with an annular chamber **160** surrounding the gas passage tube. In the form shown in FIGURE 8, the coupling or bushing **148** is fashioned with a portion **162** of an internal diameter to snugly receive an end portion of the gas passage tube **156** whereby the inlet end of the gas passage tube is supported by the coupling or bushing **148**. The overlapping contiguous regions of the gas passage tube and the coupling **148** may be spot-welded together as shown at **164**.

The inlet coupling **148** is adapted to telescopingly receive an exhaust pipe (not shown) for conveying exhaust gases into the muffler construction.

An outlet fitting **168** is fashioned with a spherically-shaped or ball portion **170** which fits in the circular opening defined by a circular edge **171** at the terminus of the curved or dome-shaped region **172** at the outlet end of the muffler shell. The terminal edge defining the opening receiving the ball-shaped portion **170** is welded as at **174** throughout the periphery of the ball-shaped portion to form a gas tight shell or joint.

FIGURE 9 illustrates a form of the invention wherein the gas passage tube of the muffler construction is supported by the couplings or bushings at the inlet and outlet ends of the muffler. The muffler shell **180** is fashioned with dome-shaped or curved end regions **181** and **182** terminating in circular edges **183** and **184** defining circular openings. An inlet coupling or bushing **185** is fashioned with a spherically-shaped or ball-like portion **186** snugly fitting into the circular opening defined by the circular edge **183**. Disposed within the muffler shell **180** is a gas pasage tube **188** having small openings **189** forming acoustic couplings with an annular chamber **190**.

The axis of the coupling or bushing **185** is aligned with the longitudinal axis of the gas passage tube **188**, the ball-shaped portion **186** of the coupling being welded as at **192** throughout its periphery to the terminal end or edge of the dome-shaped portion **181** of the muffler. The coupling or bushing **185** is provided with a cylindrical region **194** of reduced diameter to snugly yet slidably accommodate an end region **195** of the gas passage tube **188**.

The contiguous regions of the cylindrical portion **194** and the gas passage tube **188** are spot welded together as shown at **196**. In this manner, the inlet coupling or bushing **185** supports one end of the gas passage tube **188**.

A gas outlet coupling or bushing **200** is disposed at the opposite end of the muffler shell and has a spherically-shaped or ball-like configuration **202** extending into a circular opening defined by the circular edge **184** at the terminus of the dome-shaped end **182** of the muffler shell. The longitudinal axis of the coupling **200** is aligned with the axis of the gas passage tube **188**. The coupling **200** is fashioned with a cylindrically-shaped portion **204** of an internal diameter to snugly receive the end region **206** of the gas passage tube **188**, the overlapping regions of the cylindrical portion **204** and the end portion **206** of the gas passage tube being spot welded together as at **208**.

The ball-shaped portion **202** of the coupling **200** is welded as at **210** throughout its periphery to the terminal end of the dome-shaped portion **182** to form a gas tight or sealed joint. The outlet coupling **200** is adapted to telescopingly receive a tailpipe or other conventional gas conveying tube (not shown). Thus the respective ends of the gas passage tube **188** are welded to and supported by the couplings or bushings **185** and **200** and the couplings in turn welded to the one piece muffler shell **180** by the peripheral welds **192** and **210**.

It will thus be seen that in all forms of the invention, the welds between the dome-shaped ends of the one piece muffler shell and the inlet and outlet couplings or, as shown in FIGURE 7, between a ball-shaped end region of the gas passage tube and a couplings are circular welds irrespective of the angularities of the couplings or bushings with respect to the muffler shell. By providing a method of construction wherein the welding regions are circular, high speed production of welding may be attained assuring a gas tight muffler construction.

FIGURE 10 illustrates a construction similar to FIGURE 5. In the arrangement shown in FIGURE 10, the muffler shell **12***c* is fashioned with a dome-shaped end region **30***c*. The inlet coupling **38***c* is formed with a ball-shaped configuration **50***c* which extends into the circular opening defined by the terminal edge of the dome-shaped end region **30***c* of the muffler shell and is welded to the circular terminal edge as at **52***c*. A gas passage tube **212** is disposed interiorly of the shell **12***c* and is of a small diameter whereby the end **214** of the tube **212** extends into the ball-shaped configuration **50***c*. The gas passage tube **212** may be supported by one or more baffles **216**, one being illustrated in FIGURE 10. The wall of the gas passage tube at the right-end side of the baffle **216** is fashioned with a comparatively large number of small openings **218** forming acoustic couplings with the annular space between the gas passage tube **212** and the muffler shell **12***c*. By extending the gas passage tube **212** into the ball-shaped configuration **50***c*, whistling noises caused by the moving exhaust gas stream are substantially reduced.

In the forms of the invention shown in FGURES 1, 2, 4, 5, 7 and 10 the tubular couplings or bushings may be angularly adjusted to accommodate the angularities of various gas conveying pipes or tubes thus readily adapting the muffler to various installations without special couplings for each installation. In the forms shown in FIGURES 6, 8 and 9, the couplings may be employed to support one or both ends of a gas passage tube and thereby eliminate one or both partitions or headers in the muffler.

In all forms of muffler construction illustrated herein, the annular space or region between the gas passage tube and the muffler shell may be filled with sound absorbing or sound damping material such as fibrous glass or other similar material which is resistant to high temperatures.

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 comprehendnig all variations thereof.

I claim:

1. A muffler for use with the exhaust system of an internal combustion engine including a one-piece tubular shell having an integral end region of dome-shaped configuration terminating in a circular edge defining an opening, and a tubular fitting having a spherically-shaped portion extending into the opening and disposed adjacent the circular edge, the circular edge being joined to the adjacent spherically-shaped portion of the tubular fitting by welding to provide a fluid tight joint between the shell and the tubular fitting.

2. The combination according to claim **1** including tubular gas passage means mounted within the shell.

3. A muffler for use with the exhaust system of an internal combustion engine including a one-piece tubular shell having an integral smoothly curved end region of progressively decreasing diameter terminating in a circular edge defining an opening, a tubular coupling member having a spherically-shaped portion extending into the opening and disposed adjacent the circular edge, the circular edge being joined to the adjacent portion of the tubular coupling member by welding to provide a fluid tight joint between the shell and the tubular member.

4. The combination according to claim **3** including a gas passage tube mounted within the shell, said gas passage tube having open areas providing acoustic couplings with a region between the shell and the gas passage tube.

5. A muffler for use with the exhaust system of an internal combustion engine including a one-piece tubular shell having integral smoothly curved end regions of progressively decreasing diameter providing dome-shaped configurations, each configuration terminating in a cir-

cular edge defining a circular opening, tubular gas inlet and outlet fittings for the respective ends of the shell, each of said fittings having a spherically-shaped portion extending into the adjacent opening, the circular edges being joined to the adjacent spherically-shaped portions of the respective fittings by welding to provide fluid tight joints between the shell and the fittings.

6. A muffler for use with exhaust system of an internal combustion engine comprising, in combination, a one-piece tubular shell having an integral end region of dome-shaped configuration terminating in a circular edge defining an opening, tubular means having a spherically-shaped portion, the spherically-shaped portion of the tubular means being disposed in the opening and snugly engaging the circular edge, the circular edge at the end of the shell being joined to the spherically-shaped portion of said tubular means by welding the circular edge throughout its circumference to the spherically-shaped portion to provide a fluid tight joint between the shell and the tubular means.

7. The combination according to claim **6** wherein the tubular means is angularly arranged with respect to the longitudinal axis of the shell.

8. The combination according to claim **6** wherein both end regions of the tubular shell are dome-shaped configurations terminating in circular edges defining openings, and tubular means for each end of the shell, both tubular means having spherically-shaped portions joined by welding the circular edges to the spherically-shaped portions.

9. A muffler comprising, in combination, a one-piece thin-walled cylindrically-shaped shell, a gas passage tube of lesser diameter mounted within the shell, at least one end region of the shell being of progressively reduced diameter providing a dome-like configuration terminating in a circular edge defining an opening, a tubular member having a spherically-shaped portion fitting within the opening and snugly engaging the circular edge, said tubular member being adapted to be angularly disposed with respect to the axis of said shell, and fused metal bonding the circular edge of said dome-shaped configuration to the spherically-shaped portion of the tubular member throughout a peripheral region of the spherically-shaped portion forming a fluid tight joint and securing the tubular member in angularly disposed position.

10. A muffler for use with the exhaust system of an internal combustion engine comprising, in combination, a one-piece cylindrically-shaped thin-walled metal shell, the end regions of said shell being of dome-shaped configuration, each dome-shaped configuration terminating in a circular edge defining an opening, a tubular gas inlet fitting for one end of said shell, a tubular gas outlet fitting for the other end of said shell, each of said fittings having a spherically-shaped portion extending into the opening at an end of the shell and snugly engaging the circular edge, said spherically-shaped portions of said fittings being welded to the circular edge regions of dome-shaped portions defining the openings to form gas tight joints, and a gas passage tube disposed within said shell, the wall of said gas passage tube having small openings therein forming acoustic couplings with a space surrounding the gas passage tube.

11. The combination recited in claim **10** including a partition in said shell providing support means for the gas passage tube.

12. The combination according to claim **10** including a partition in said shell providing support means for an end region of the gas passage tube, the other end of said gas passage tube being in engagement with and supported by one of said tubular fittings.

13. The combination according to claim **10** wherein the respective ends of the gas passage tube are in engagement with said inlet and outlet fittings whereby the gas passage tube is supported by said fittings.

14. A muffler comprising, in combination, a one-piece tubular shell of substantially cylindrical configuration, an end region of said tubular shell being of progressively reduced diameter providing a dome-shaped configuration terminating in a circular edge defining an opening, a tubular coupling member having a spherically-shaped portion snugly fitting within said opening, fused metal bonding the circular edge region of said dome-shaped configuration to the spherically-shaped configuration to form a fluid tight joint, the tubular coupling member having a cylindrical extension within the shell of lesser diameter than the diameter of the exterior surface of the spherically-shaped configuration and integrally joined with the spherically-shaped configuration, and a gas passage tube disposed within the shell having an end region in overlapping relation with said extension providing support means for the gas passage tube, said gas passage tube having a plurality of openings in the wall thereof providing acoustic couplings with the space surrounding the gas passage tube.

15. The method of producing a muffler comprising the steps of progressively reducing an end region of a thin walled tubular shell to form a dome-shaped configuration terminating in a circular edge defining an opening, positioning a spherically-shaped portion of a tubular coupling in the circular opening with the circular edge snugly engaging the spherically-shaped portion, and welding the circular edge to the spherically-shaped portion throughout its periphery to form a gas tight seal.

16. The method according to claim **15** including the step of adjusting the tubular coupling at an angle with respect to the longitudinal axis of the tubular shell prior to welding the circular edge to the spherically-shaped portion.

References Cited

UNITED STATES PATENTS

1,838,249	12/1931	Brown	285—286
1,972,065	8/1934	Noblitt	181—48
2,035,923	3/1936	Scarritt	181—48
2,485,392	10/1949	Leadbetter	181—48
2,553,326	5/1951	Manning	181—61
2,598,756	6/1952	Brightly et al.	181—61
2,872,998	2/1959	Tinker	181—61
3,159,239	12/1964	Andrews	181—61
3,274,678	9/1966	Andrews	29—471.1

FOREIGN PATENTS

877,911	9/1942	France.

ROBERT S. WARD, JR., *Primary Examiner.*