May 4, 1965 E. H. SCHOMBURG 3,181,647

APPARATUS FOR MUFFLING NOISE AND ENGINE EXHAUST GASES

Filed Oct. 18, 1963

2 Sheets-Sheet 1

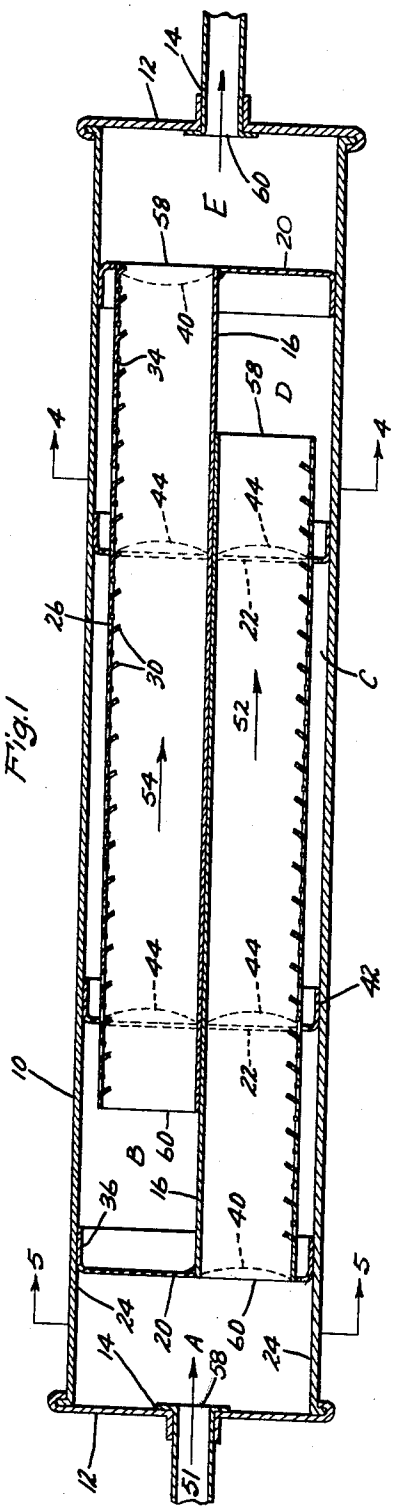


Fig. 1

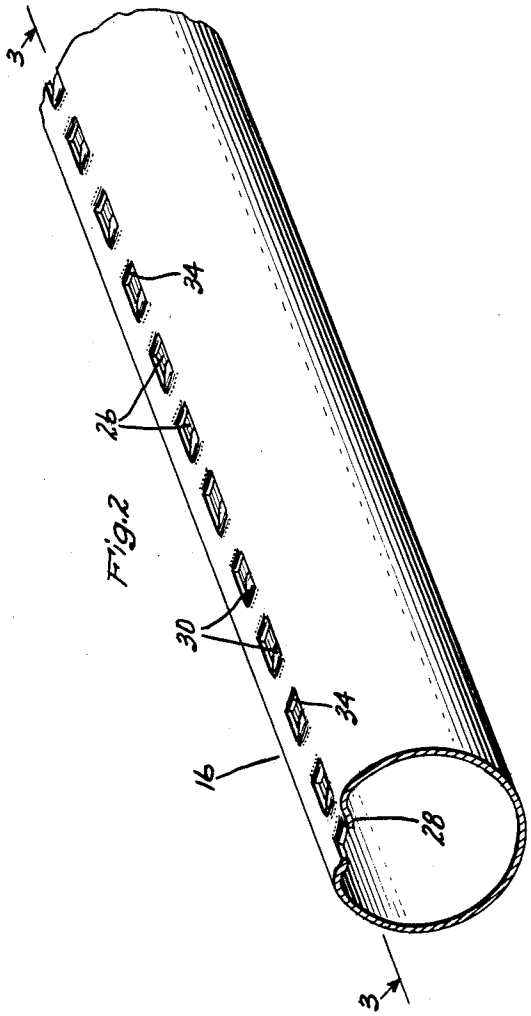


Fig. 2

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Fig.3

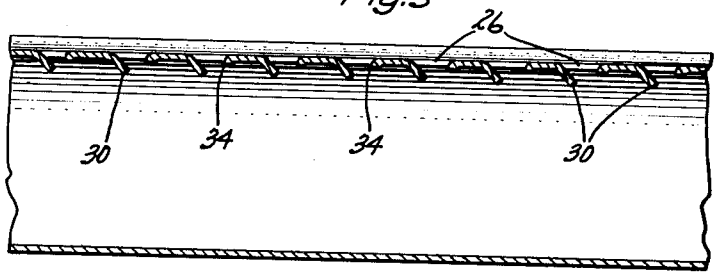


Fig.4

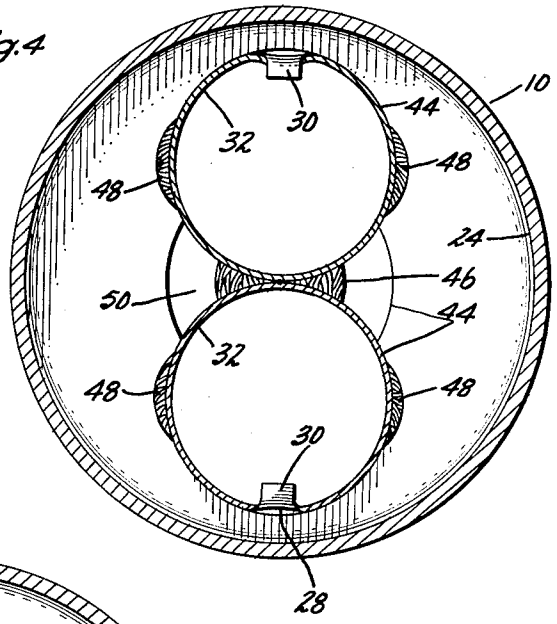
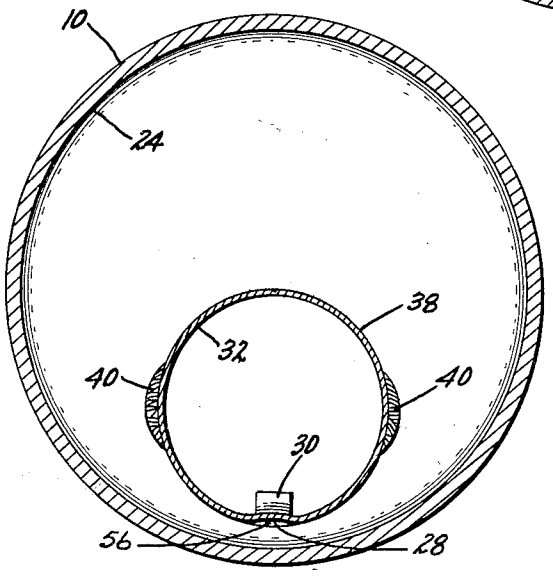


Fig.5



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United States Patent Office 3,181,647
Patented May 4, 1965

3,181,647

APPARATUS FOR MUFFLING NOISE AND ENGINE EXHAUST GASES

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Filed Oct. 18, 1963, Ser. No. 317,186
6 Claims. (Cl. 181—54)

The present invention relates to an apparatus and method of muffling noise and more particularly to muffling noises in the exhaust gases of internal combustion, reciprocating, piston-type engines.

Mufflers used in conjunction with internal combustion, reciprocating piston-type engines are conventionally connected to the exhaust pipe circuit of the engine so that the exhaust gases must pass therethrough before being exhausted into the atmosphere. Several varieties and designs of mufflers have been proposed, all of which operate on the same physical principles. It is generally known that sound waves traveling through air have appreciably straight paths, absent any interference from other objects. Only by reflecting from relatively solid objects do sound waves travel around corners. It is also readily known that sound waves are continuously being reduced in loudness by the cushioning effect of the supporting gas medium either upon a reflection or change in direction, an encounter with air turbulence, or an impingement upon a relatively stagnant gas. Energy is thus lost from the sound wave, resulting in a muffling of the sound. While numerous mufflers have been proposed, all of the designs have a series of restricted passages through which the exhaust gases must pass. These restrictions set up various amounts of turbulence and tagnant air pockets. Mufflers that have been proposed utilize various and sundry structures for this purpose and result in various degrees of success in muffling engine noises.

Prior mufflers have been generally of two types: single-pass mufflers and multi-pass mufflers. Of these types, the multi-pass muffler has greater capabilities of muffling noises in exhaust gases due to the several changes of direction in gas flow within such mufflers and therefore are highly desirable. However, every change of direction of gas flow or restriction of gas flow results in a requisite pressure drop. This places a limitation on the number of restrictions or flow reversions possible in any given muffler as the exhaust gases of the engine must be permitted to flow out of the engine cylinder for preferred engine operation. Whenever the flow restriction becomes appreciable across any muffler system, a portion of the exhaust gases are left in the engine cylinder thereby occupying space that could be occupied by a combustible air-gasoline mixture. This results in a direct loss of power and a less efficient engine operation. It is therefore desirable to provide a simple, inexpensive and efficient multi-pass muffler for internal combustion engines, having a relatively unrestricted gas flow therethrough. While various multi-pass muffler systems have been proposed, those having relatively unrestricted gas flow have not had sufficient muffling properties, while those having sufficient muffling properties have generally caused losses in engine performance and economy. It is therefore desirable to provide a new and novel method of muffling exhaust gases from internal combustion engines that can be incorporated into a muffler having the aforementioned desired qualities.

It is therefore an object of this invention to provide a unique method of muffling exhaust gases from internal combustion engines that is easily and inexpensively employed in a muffler structure that has efficient muffling properties and does not appreciably restrict gas flow therethrough.

It is another object of this invention to provide an improved muffler utilizing the unique method of this invention.

It is still another object of this invention to provide an improved multi-pass muffler system wherethrough gas flow is relatively unrestricted.

It is still another object of this invention to provide a simple, efficient and inexpensive multi-pass muffler structure.

Further objects and advantages of my invention will become apparent by reference to the following description and the accompanying drawings and the features of novelty which characterize my invention will be pointed out with particularity in the claims annexed to and forming a part of this specification.

The invention in its broader aspects provides a method of silencing noises in flowing gas streams comprising the steps of selectively varying the gas velocity, beneficially introducing turbulence into the flowing gases, and reversing the direction of the flow of gases at various times before the flow of gases are exhausted to the atmosphere.

The invention in its broader aspects also provides an engine muffler comprising a first chamber, a tube leading to the second chamber, a plurality of third chambers mounted by perforated baffles, a fourth chamber, a tube leading from the fourth chamber to the fifth chamber, and an exit leading therefrom to the atmosphere.

In the drawings, each figure is drawn to scale:

FIG. 1 is a side view, in cross-section of a three-pass muffler, an apparatus that utilizes the unique method of this invention;

FIG. 2 is a perspective view of the perforated tubes incorporated in the muffler of FIG. 1;

FIG. 3 is a cross-sectional fragmentary view taken along the line 3—3 of FIG. 2;

FIG. 4 is a cross-sectional view taken along the line 4—4 of FIG. 1; and

FIG. 5 is a cross-sectional view taken along the line 5—5 of FIG. 1.

Referring to the drawings, there is shown at **10** a metallic muffler barrel that is closed at both ends by closure plates **12** having central openings **14** through which exhaust gases enter and exit from the muffler. Fixedly positioned within barrel **10** are two metal tubes **16** substantially equal in length and identical in all respects, which are fixedly attached to each other at their surfaces in a manner that their axes are parallel and define a single plane. Tubes **16** are not coterminous, each tube is longitudinally offset to the other having approximately one-third of its length overhanging one end of the other tube. Mounted in this fashion, tubes **16** are fixedly attached within barrel **10** essentially equally distant from end plates **12** and centrally located in the circular cross-section of the barrel **10** by means of baffle plates **20** and **22** which are secured to tubes **16** and the inner surface **24** of barrel **10**.

Tubes **16** are slightly deformed from a generally cylindrical shape by means of a longitudinal indentation **28** in the tubes surface. As more clearly shown in FIGS. 2, 4 and 5, the crossection of tube **16** is circular except for the indentation **28**. Indentation **28** is formed during the process of cutting pressure relief holes **26** which are aligned with and located at the bottom of longitudinal indentation **28** in tubes **16**. A line drawn through the centers of pressure relief holes **26** on the surface of each of tubes **16** is parallel and in a plane with the axis of the tube **16** as they are mounted in barrel **10**. Pressure relief holes **26** are formed in tube **16** by cutting two relatively short longitudinal and paraliel slits in tube **16** aligned with the axes thereof, and connecting the ends of the two slits by a third slit, thereby forming a rectangular tab **30**. Tab **30** is then pressed into said tube form-

ing a pressure relief hole 26 and at the same time tab 30 is formed and positioned so as to protrude from the interior surface 32 of tube 16. In production, pressure relief holes 26 are made in a single press-stamping operation that slits tube 16 and depresses tab 30 into tube 16 all in a single operation. Because of the force applied to tube 16 during this press stamping operation, longitudinal indentation 28 is formed. Also because of the method of forming pressure relief holes 26, the hole edge perpendicular to the tube axes has at the interior surface 32 a knife edge 34. In the muffler shown in FIG. 1, tubes 16 are fastened together in such a manner that tabs 30 slope in the direction of gas flow and knife edges 34 face in the opposite direction. However, for other applications, tabs 30 and knife edges 34 may be positioned in opposite directions.

Baffle plates 20, more clearly shown in FIG. 5, are disc-shaped, having a perpendicular, annular flange 36 and a single opening 38 therein. Opening 38 is circular, having a diameter approximately equal to the outside diameter of tube 16 and having as one point on its circumference the center of the disc-shaped baffle plate 20. In assembling the muffler of FIG. 1, a single tube 16 is inserted into hole 38 such that longitudinal indentation 28 is most adjacent interior surface 24 of barrel 10. Baffle 20 is secured to tube 16 adjacent an end by welding at 40 and secured to interior surface 24 of barrel 10 solely by means of a frictional fit between flange 36 and surface 24.

Baffles 22, more clearly shown in FIG. 4, are disc-shaped and have a perpendicular annular flange 42. Baffles 22 have three circular openings 44 which overlap and form a single opening therein, each circular opening 44 having a diameter approximating the diameter of tubes 16 and each having its center located on the same diameter of baffle 22. One of the three openings 44 has as its center the center of baffle 22, the other openings 44 have the center of baffle 22 as a point on the circumference, thereby providing for an ample overlap of the three circular openings. In assembling the muffler of FIG. 1, tubes 16 are inserted into the two outermost openings 44 with their pressure relief openings 26 most adjacent the inner surface 24 of barrel 10. Tubes 16 are then welded together at 46 and secured to baffle plate 22 by welding at 48. Approximately one-third of the central opening 44 is left unobstructed, thereby forming openings 50 on either side of tubes 16. Baffle plates 22 are secured to barrel 10 solely by means of a frictional fit between annular flange 42 and interior surface 24.

As assembled, the three-pass muffler shown in FIG. 1 is divided into five compartments, indicated by A, B, C, D, E, respectively. Compartments A and E are relatively sealed except for the relatively small opening 56 between the longitudinal indentation 28 and baffles 20 and 22 (see FIG. 5); compartments B, C and D are relatively loosely sealed, having interconnecting openings 50 in baffle plates 22. Compartments A and D and compartments B and E are directly interconnected by means of tubes 16; compartments B, C and C, D are directly interconnected by openings 50. The other combinations of the compartments as above-mentioned, i.e., A and B, A and C, A and E, B and D, C and E, C and D, and D and E, are connected only by means including the openings 26 in the tubes 16 and spaced from each other. In actuality, however, pressure relief holes 26 allow gases passing from chamber A to D and chamber B to E, through tube 16, to leak into chambers B and C and chambers C and D, respectively.

The three-pass muffler illustrated in FIG. 1 utilizes the method of this invention of silencing noises. Therefore, the detailed description of the operation of the muffler of FIG. 1 will also describe the method of my invention. As is evident from the physical laws governing gas flow, turbulence is interjected into the flowing gas stream at several points within the muffler structure shown in FIG. 1. To enumerate only the more obvious turbulence-forming structures, attention should be directed to each of the exits 58 of relatively small tubes into relatively large chambers and the reversal of gas flow after each exit 58, each of the entrances 60 of relatively small tubes from relatively large chambers, the tabs 30 protruding from the interior surface 32 of tube 16, and the orifice type structures of openings 50 in baffle plates 22.

As is further evident from the physical laws governing gas flow, the gas flows between tubes 16 and chambers A, B, C, D and E and between adjacent chambers are solely controlled by the relative dimensioning of the respective openings therebetween. As described herein, the magnitude of each gas flow and their relative size to each other provide the improved muffling characteristics of the specific embodiment shown in the scale drawings of FIGS. 1 to 5. In that specific embodiment, barrel 10 has a diameter of four (4) inches. Tubes 16 have a diameter of one and three-quarters (1¾) inches and a single row of pressure relief holes 26 extending axially, the holes 26 being on one-half (½) inch centers and one-quarter (¼) inch square.

In operations, engine exhaust gases enter through hole 14 in closure plate 12 into chamber A in the direction shown by arrow 51. The gases collected in chamber A are then removed from chamber A by means of tube 16, having tabs 30 sloped in the direction of flow indicated by arrow 52. The exhaust gases are increased in velocity upon entrance into tube 16 by means of the relatively small cross-section of tube 16 compared to that of chamber A. Pressure relief openings 26 allow a portion of the exhaust gases flowing through tube 16 to escape into chambers B and C, resulting in a gas pressure within tube 16 lower than that calculable by normal gas flow equations. Gases flowing through tube 16 then exit into chamber D and are impinged against a relatively stagnant gas layer adjacent baffle 20. Upon exit from the tube 16, the gas pressure is further reduced by the expansion of the gas into the larger diametered chamber D, thereby further reducing the gas pressure in chamber D from that of chamber A. The exhaust gases pass from chamber D through openings 50 in baffle plates 22 into chamber C, thereby flowing in a direction opposite that shown by arrow 52. The velocity of the gases in chamber D is relatively slower than the velocity of the gases flowing through tube 16, as aforementioned, and likewise the velocity of the gases flowing through openings 50 is relatively faster than either the gas velocity in chamber D or in chamber C. Also, a further drop in pressure is observed as the gases flow through opening 50 from chamber D to chamber C, thereby providing a lower pressure in Chamber C than in chamber D and an appreciably lower pressure in chamber C than in tube 16 flowing into chamber D, thereby providing for a gas flow from tube 16 to chamber C. Gases from chamber C exit either into chamber B through openings 50 of baffle plates 22 or exit through pressure relief holes 26 into the tube 16 transporting gases from chamber B to chamber E in the direction of arrow 54. The gases flowing into chamber B from chamber C experience a pressure drop and an increased velocity traveling through the openings 50 similarly to the flow of gases from chamber D into chamber C. Thus the flow of gases through openings 50 in baffle plates 22 provides a lower gas pressure in chamber B than in chamber D or chamber C. Relatively swift gases emerging from openings 50 into chamber B are impinged against another relatively stagnant gas layer immediately adjacent baffle 20, and thereupon, reversed in the direction of flow so as to enter the second-mentioned tube 16, exiting from chamber B and interconnecting chambers B and E. Gases of chamber B upon entering tube 16 are further reduced in pressure and are again increased in velocity. As gases from chamber C are entering tube 16, as well as gases from chamber B, more gas arrives at chamber 9 than enters tube 16 from chamber B. All of the gas entering tube 16 from chamber A eventually ar-

rives in chamber E and collects until exited through opening 14 in closure plate 12.

While there have been described above the principles of this invention in connection with specific apparatus, it is to be clearly understood that this description is made only by way of example and not as a limitation to the scope of the invention.

What is claimed is:

1. A three-pass engine muffler comprising an elongated tubular barrel having an axis and opposite first and second ends; first and second elongated tube members having axes and being disposed within said barrel, the axes of said barrel and tube members being parallel and lying in a single plane, said tube members being of substantially equal size and being secured together in side-by-side and longtitudinally offset relation whereby one end portion of each tube member extends beyond the adjacent end of the other tube member, two closure plates on the opposite ends, respectively, of said barrel, entrance and exhaust tubes secured to said two closure plates, respectively, communicating with the interior of said barrel, a first disc-shaped baffle plate having an axially extending flange on the perimeter thereof, said baffle plate being frictionally fitted into said barrel and being disposed at right angles to the axis of said barrel, said first baffle plate being spaced from one of said closure plates thereby forming a first compartment therewith, said baffle plate having an opening which receives in sealing relation the distal end of the end portion of one tube member thereby establishing communication between said first compartment and said one tube member, a second disc-shaped baffle plate having an axially extending flange on the perimeter thereof, said second baffle plate being frictionally fitted into said barrel and being disposed at right angles to the axis of said barrel, said second baffle plate being spaced from the other of said closure plates thereby forming a second compartment therewith, said second baffle plate having an opening which receives in sealing relation the distal end of the end portion of the other tube member thereby establishing communication between said second compartment and said other tube member, both said tube members having a plurality of longitudinally spaced apertures therein arranged in a straight line located in said plane of said axes adjacent to the periphery of said barrel, said apertures extending from one end to the other of each tube member, a plurality of deflector tabs on said tube members adjacent to said apertures, respectively, and extending inwardly of said tube members,, there being one tab for each aperture, said tabs being secured to said tube members and angling inwardly in a direction extending from said first barrel end toward the second barrel end, and a third disc-shaped baffle plate having an axially extending flange on the perimeter thereof, said third baffle plate being frictionally fitted into said barrel and being disposed at right angles to the axis of said barrel, said third baffle plate being spaced from and disposed between said first and second baffle plates thereby defining additional compartments, said third baffle plate having two diametrically spaced openings which receive, respectively, said two tube members, said third baffle plate being secured to said two tube members, and a clearance opening provided in said third baffle plate in the central portion theresof adjacent to said two tube members for providing direct communication between said additional compartments.

2. The muffler of claim 1 including a fourth disc-shaped baffle plate having an axially extending flange on the perimeter thereof, said fourth baffle plate being frictionally fitted into said barrel and being disposed at right angles to the axis of said barrel, said fourth plate having three diametrically spaced openings, the outermost of the last-mentioned openings, respectively, receiving said two tube members, said fourth baffle plate being secured to said two tube members, the middle of said three openings forming a clearance between said fourth plate and said tube members for providing direct communication between the compartments on opposite sides of said fourth plate, said third and fourth baffle plates being spaced from each other and from said first and second baffle plates thereby defining three tandemly arranged compartments, the two ends of said two tube members which are set back from said end portions communicating with the two endmost of said three compartments, respectively.

3. A three-pass engine muffler comprising an elongated tubular barrel having an axis and opposite first and second ends; first and second elongated tube members having axes and being disposed within said barrel, the axes of said barrel and tube members being parallel and lying in a single plane, said tube members being of substantially equal size and being secured together in side-by-side and longitudinally offset relation whereby one end portion of each tube member extends beyond the adjacent end of the other tube member, two closure plates on the opposite ends, respectively, of said barrel, entrance and exhaust tubes secured to said two closure plates, respectively, communicating with the interior of said barrel, a first disc-shaped baffle plate fitted into said barrel and being disposed at right angles to the axis of said barrel, said first baffle plate being spaced from one of said closure plates thereby forming a first compartment therewith, said baffle plate having an opening which receives in sealing relation to distal end of the end portion of one tube member thereby establishing communication between said first compartment and said one tube member, a second disc-shaped baffle plate fitted into said barrel and being disposed at right angles to the axis of said barrel, said second baffle plate being spaced from the other of said closure plates thereby forming a second compartment therewith, said second baffle plate having an opening which receives in sealing relation the distal end of the end portion of the other tube member thereby establishing communication between said second compartment and said other tube member, both said tube members having a plurality of longitudinally spaced apertures therein arranged in a straight line located in said plane of said axes adjacent to the periphery of said barrel, said apertures extending from one end to the other of each tube member, a plurality of deflector tabs on said tube members adjacent to said apertures, respectively, and extending inwardly of said tube members, there being one tab for each aperture, said tabs being secured to said tube members and angling inwardly in a direction extending from said first barrel end toward the second barrel end, and a third disc-shaped baffle plate fitted into said barrel and being disposed at right angles to the axis of said barrel, said third baffle plate being spaced from and disposed between said first and second baffle plates thereby defining additional compartments, said third baffle plate having two diametrically spaced openings which receive, respectively, said two tube members, said third baffle plate being secured to said two tube members, and a clearance opening provided in said third baffle plate in the central portion thereof adjacent to said two tube members for providing direct communication between said additional compartments.

4. A multi-pass engine muffler comprising a barrel having intake and exhaust chambers at the opposite ends thereof, respectively, partition means providing a plurality of intermediate chambers tandemly arranged between said intake and exhaust chambers, said partition means having apertures therein thereby providing communication between adjacent ones of said intermediate chambers, a first elongated conduit interconnecting said intake and one of said intermediate chambers, a second of said intermediate chambers being between said intake and said one intermediate chamber, a second elongated conduit interconnecting said exhaust chamber and another of said intermediate chambers, both said intake and exhaust conduits having orifices in the walls thereof, said orifices interconnecting said conduits and said intermediate chambers, said intake and exhaust chambers be-

ing interconnected by said conduits, orifices and apertures, whereby gases flowing generally in the direction from said intake chamber to said exhaust chamber passes, in reverse directions longitudinally of said barrel, and also transversely of said barrel, said gases also impinging upon said partition means and the inner wall of said barrel in the process of muffling exhaust gases.

5. A three-pass engine muffler comprising an elongated barrel, first and second conduits having axes and being disposed within said barrel, said axes of said conduits being parallel and lying in a single plane which also includes the cross-sectional diameters of said barrel, said conduits being secured in longitudinally offset relation whereby one distal end portion of each conduit extends beyond the adjacent end of the other conduit, two closure plates on opposite ends, respectively, of said barrel, entrance and exhaust ducts secured to said two closure plates, respectively, communicating with the interior of said barrel, a first baffle plate being spaced from one of said closure plates, thereby forming a first compartment therewith, said first baffle plate having a first opening therein, said first opening receiving in sealing relation said distal end portion of one of said conduits, said first baffle plate being in sealing relation with said barrel, a second baffle plate being spaced from the other of said closure plates thereby forming a second compartment therewith, said second baffle plate having a second opening therein, said second opening receiving in sealing relation said distal end portion of the other of said conduits, said second baffle plate being in sealing relation with said barrel, both said conduit members having a plurality of longitudinally spaced apertures therein arranged in a straight line, said straight line being located in said plane of said conduit axes with both of said axes lying in said plane between said line of said first conduit and said line of said second conduit, said apertures extending from one end to the other end of each conduit and being adjacent the periphery of said barrel, a plurality of deflector tabs on said conduit members adjacent to said apertures, respectively, and extending inwardly of said conduit members and angling in a direction extending from said entrance duct toward said exhaust duct, there being one tab for each aperture, and at least one third baffle plate intermediate and spaced from said first and second baffle plates thereby forming additional compartments, said third baffle plate having a third opening therein, said first and second conduits passing through said third opening, said third baffle plate being secured to said barrel and said conduits.

6. A three-pass engine muffler comprising an elongated barrel, first and second conduits having axes and being disposed within said barrel, the axes of said conduits being parallel and lying in a single plane which also includes the cross-sectional diameters of said barrel, said conduits being secured in longitudinally offset relation

whereby one distal end portion of each conduit extends beyond the adjacent end of the other conduit, two closure plates on opposite ends, respectively, of said barrel, entrance and exhaust ducts secured to said two closure plates, respectively, communicating with the interior of said barrel, a first baffle plate being spaced from one of said closure plates thereby forming a first compartment therewith, said first baffle plate having a first opening therein, said first opening receiving in sealing relation said distal end portion of one of said conduits, said first baffle plate being in sealing relation with said barrel, a second baffle plate being spaced from the other of said closure plates thereby forming a second compartment therewith, said second baffle plate having a second opening therein, said second opening receiving in sealing relation said distal end portion of the other of said conduits, said second baffle plate being in sealing relation with said barrel, both said conduit members having a plurality of longitudinally spaced apertures therein arranged in a straight line, said straight line being located in said plane of said conduit axes with both of said axes lying in said plane between said line of said first conduit and said line of said second conduit, said apertures extending from one end to the other end of each conduit and being adjacent the periphery of said barrel, a plurality of deflector tabs on said conduit members adjacent to said apertures, respectively, and extending inwardly of said conduit members and angling in a direction extending from said entrance duct toward said exhaust duct, there being one tab for each aperture, and a third baffle plate secured in said barrel between said first and second baffle plates in spaced relation thereto thereby defining additional compartments, said third baffle plate having two diametrically spaced openings which reecive said two conduits, respectively, said third baffle plate being sealingly secured to said two conduits and said barrel and having an orifice therein, said orifice providing communication between said additional compartments, said orifices interconnecting said additional chambers.

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