

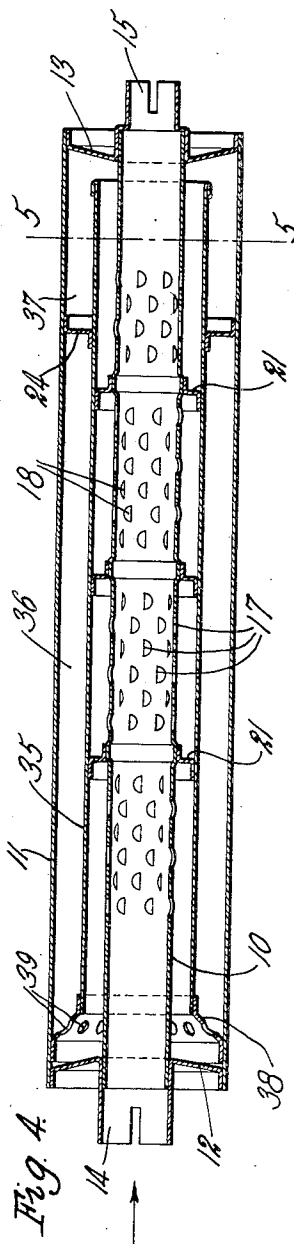
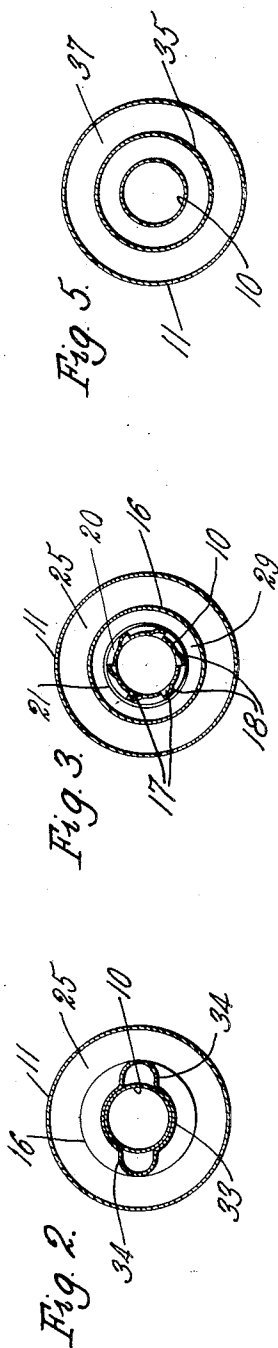
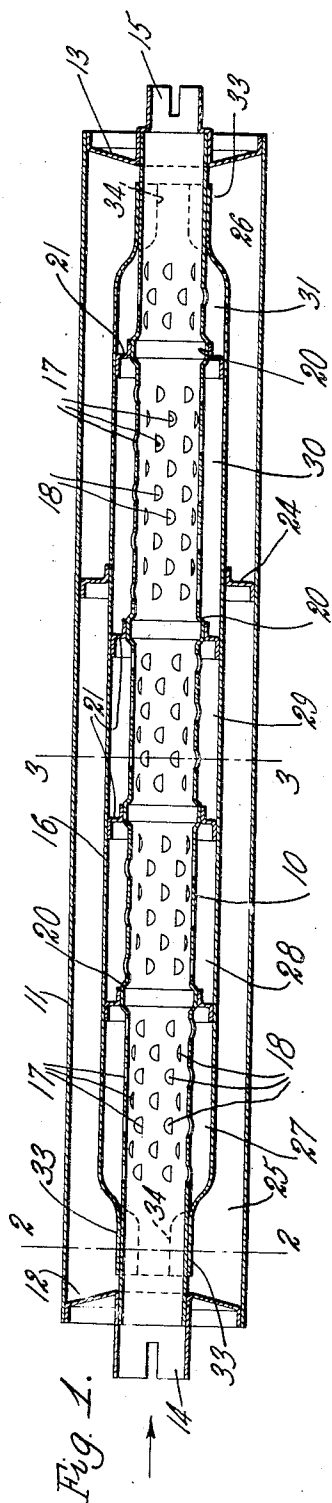
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R. J. MacKENZIE ET AL
MUFFLER

2,188,202

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2 Sheets-Sheet 1



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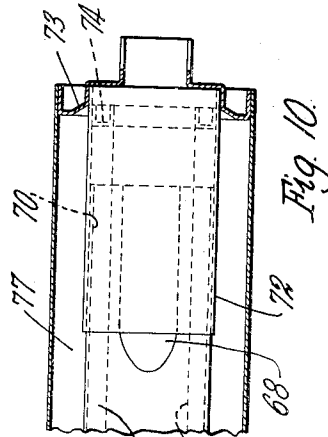
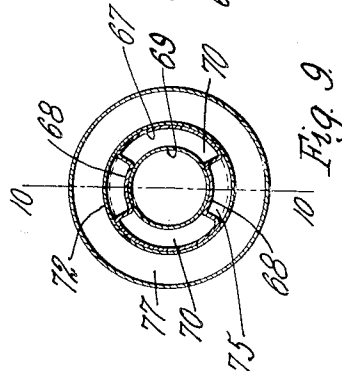
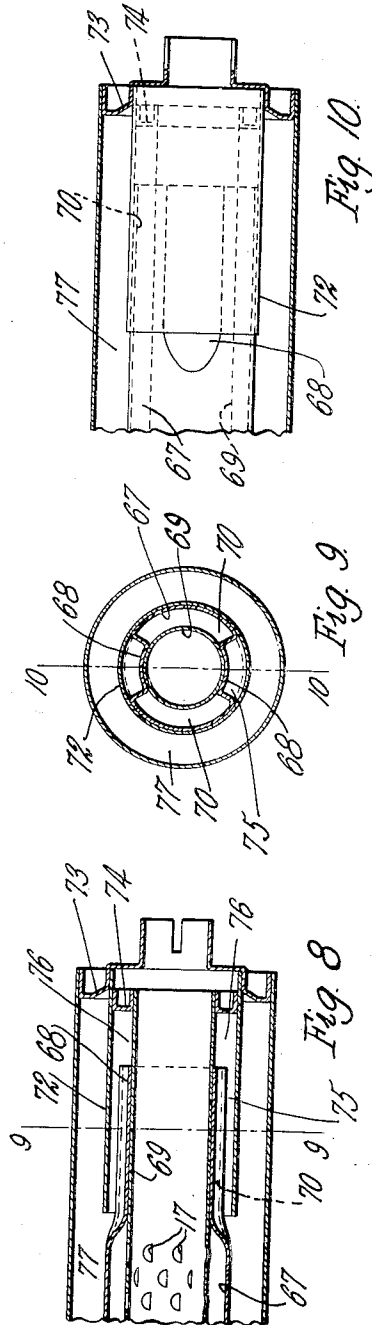
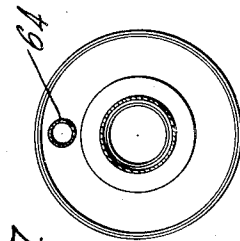
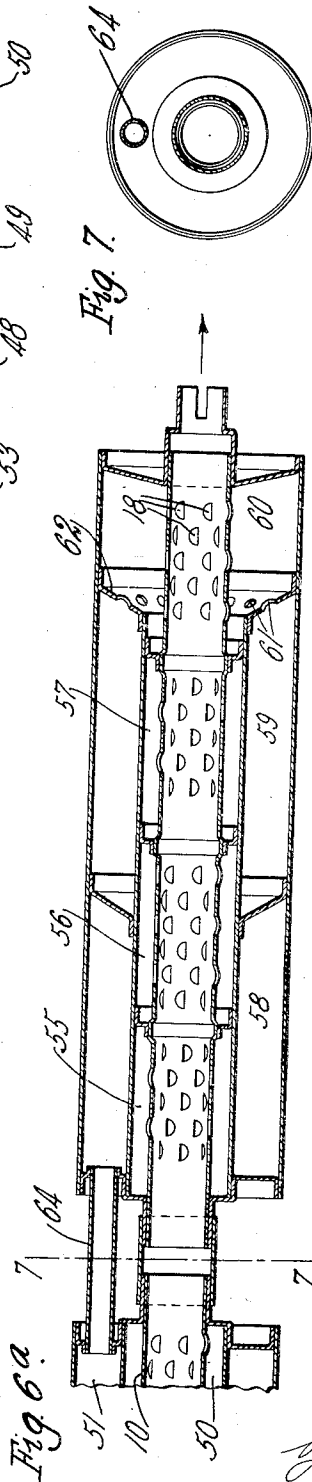
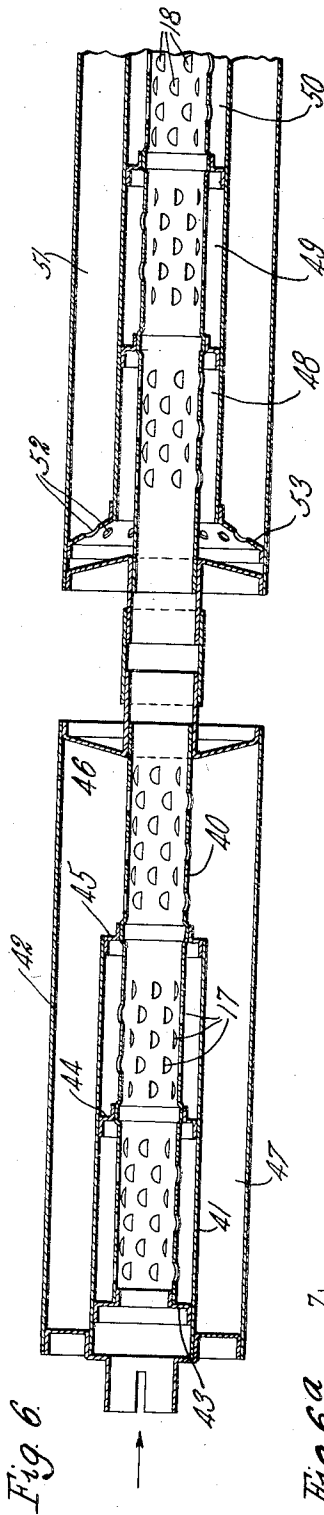
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MUFFLER

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2 Sheets-Sheet 2



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2,188,202

MUFFLER

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15 Claims. (Cl. 181—48)

This invention relates to improvements in mufflers or silencers of the type intended to silence the noise accompanying a stream of gases, as, for example, happens in connection with the exhaust of an internal combustion engine.

The objects of this invention are to provide an improved structure of this kind having an inner passage or shell for the gases which is provided along the greater portion of its length with a large number of relatively small apertures, and having sound deadening chambers of improved construction arranged about said inner shell; also to provide a muffler having a plurality of spaces, each successively communicating with another to receive sound waves and gases, and having means to cause gases to move in different directions in different chambers, and to pass from one chamber to another in a direction substantially at right angles to the direction of movement of the gases in the other chamber; also to provide an improved method of muffling sound by means of which sound waves travel to and from bodies of gases in a direction substantially at right angles to the direction of motion imparted to the gas as it moves through the perforations in the inner shell into the chambers occupied by these bodies of gas; also to provide an inner shell of this kind and having portions of the inner shell projecting outwardly at or near said apertures, and also having one or more outwardly extending annular ridges or projections to which baffles or the like may be secured between series of said apertures; also to provide a muffler of this kind in which two or more chambers are provided which are connected by means of one or more sound-conducting channel or neck portions; also to provide a muffler of this kind provided with an inner shell through which the gases flow lengthwise, and a plurality of chambers formed about the inner shell in which the gases flow in a substantially circumferential or tangential direction relatively to the inner shell; also to provide a muffler of this kind in which some of the chambers having a substantially circumferential motion are connected with resonator chambers; also to improve the construction of mufflers of this type in other respects hereinafter specified.

In the accompanying drawings:

Fig. 1 is a longitudinal central sectional view of a muffler embodying this invention.

Figs. 2 and 3 are transverse sectional elevations thereof on lines 2—2 and 3—3, respectively, of Fig. 1.

Fig. 4 is a longitudinal central sectional view of a muffler of modified construction.

Fig. 5 is a transverse sectional elevation thereof on line 5—5, Fig. 4.

Fig. 6 is a longitudinal central sectional elevation of a portion of a muffler of still another modi-

fied construction, and Fig. 6a is the remaining portion or continuation of the same muffler.

Fig. 7 is a transverse sectional elevation thereof on line 7—7, Fig. 6a.

Fig. 8 is a fragmentary longitudinal central sectional elevation of the end portion of a muffler of modified construction.

Fig. 9 is a transverse sectional elevation thereof on line 9—9, Fig. 8.

Fig. 10 is a fragmentary longitudinal central sectional view thereof on line 10—10, Fig. 9.

In all of the several constructions shown, we have provided a substantially continuous straight through passage for gases and sound waves and about this passage are arranged a series of chambers into some of which gases pass through perforations or apertures in the passage, and in such chambers means are provided for imparting movement to the gases, such for example as a whirling movement on a motion substantially tangential to the circumference of the perforated shell. Other or secondary chambers connect with the chambers containing moving gases and receive sound waves and gases in a direction at an angle to the direction at which the gases emerge from the perforated shell, and sound waves on reflection from these secondary chambers are returned to the first chambers in a direction such that they encounter the circumferential motion of the gases in these chambers at an angle and likewise the sound waves carried by this moving gas, thus causing interference and modification of these sound waves in such a manner as to decrease the intensity of the sound waves.

Referring to Figs. 1 to 3, the muffler includes an inner shell, tube or conduit 10 having perforations throughout the greater portion of the length thereof, an outer imperforate shell 11, and baffles or heads 12 and 13 which may form end walls of the muffler, and which, in the particular construction shown, extend from the outer to the inner shell and are secured to both of these shells. These baffles or heads preferably have tubular projections 14 and 15 to which pipes or tubes carrying the stream of gases may be connected. When the muffler is used for silencing the exhaust of an internal combustion engine, the exhaust pipe is connected with the projection 14 at the inlet end of the muffler and the usual tail pipe may be connected to the projection 15. The muffler also includes one or more intermediate shells, a single intermediate shell 16 being shown in the construction illustrated in Figs. 1 to 3.

The inner shell is provided with a relatively large number of perforations 17 extending throughout the greater portion of the length thereof and the metal adjacent to these perforations is preferably formed or drawn outwardly in such a manner as to form louvers or vanes 18

which serve to deflect or guide the gases passing out through the apertures in a substantially tangential direction. A series of these louvers arranged about a circumferential portion of the inner shell will produce a strobic action or tangential motion of gases in the chamber surrounding the inner shell, and the sound waves passing out through these openings will be deflected in a similar manner. The louvers in the inner shell may extend all in one direction so as to cause all of the gases between the inner and intermediate shells to move in the same direction, or the gases in different portions of the space between the inner and intermediate shells may be discharged in different directions. If desired, the gases in a single chamber surrounding the inner shell may be divided into two or more bodies and adjacent bodies may whirl in opposite directions, this being effected by a corresponding arrangement of the louvers.

These perforations in the inner shell, in the form shown in the drawings, are elongated, being several times longer than their widths, and they are arranged non-perpendicular to the general direction of flow of gases through the inner shell. The perforations present sharp corners at the leading and trailing ends thereof and have no faces which are perpendicular to the flow of gases in the inner shell. Because of this structure, the perforations avoid the creation of whistling or hissing sounds sometimes produced by circular perforations.

It is desirable to divide the space between the inner and intermediate shells into a series of chambers, some of which may be of different lengths than others. It is, of course, customary to divide the space between two tubular shells by means of baffles, but where projections or louvers extend outwardly from the outer surface of the inner shell, the securing of baffles to the inner shell to form substantially air-tight joints therewith is not possible with such inner shells as ordinarily constructed. To overcome this difficulty, we have provided the inner shell at the portions thereof at which the baffles are to be arranged with outwardly extending annular ridges or raised portions, see Figs. 1 and 3, the outer surfaces of these annular ridges extending outwardly beyond the cylindrical surface of the inner shell to an extent equal to or greater than the extent to which the louvers extend outwardly. Consequently, in the assembly of a muffler, baffles may be passed lengthwise of the inner shell, thus clearing the louvers, and such baffles will fit snugly against the annular ridges and may be spot-welded or otherwise secured thereto.

24 represents a baffle spaced between the intermediate and outer shells to divide the space between these shells into two outer chambers. One or more of these baffles may be employed, as desired, or such baffles may be entirely omitted. In the construction shown in Fig. 1, this baffle divides the space between the intermediate and outer shells into two outer chambers and the space between the inner and intermediate shells is divided into inner chambers, 27, 28, 29, 30 and 31.

The two end chambers 27 and 31 are preferably connected with the outer chambers 25 and 26 respectively by means of passages in the muffler which are so arranged that sound can travel into the outer chambers 25 and 26 only after it has been acted upon by the inner chambers 27 and 31, or in other words, the connecting passages or

channels between the two inner and outer chambers are such that sound cannot pass directly from the interior of the inner shell to the outer chambers. It has been found that very decidedly silencing effects are produced in this manner, and these results can, of course, be obtained by means of a number of different constructions, those illustrated in the drawings being merely examples showing how our invention may be used. It is not intended to limit this invention to the construction illustrated.

In certain cases, superior results are obtained when the passage connecting an inner and an outer chamber is of restricted nature. If such an arrangement is desired, this can be accomplished by means of the construction shown in Fig. 1, in which the end portions of the intermediate shell are deformed out of their cylindrical shape in such a manner that portions of the intermediate shell will lie in contact with portions of the inner shell, see particularly Fig. 2, while other portions of the ends of the intermediate shell are left in an outwardly bowed form to form constricted sound conducting channels leading from the inner chambers 27 and 31 to the outer chambers 25 and 26 respectively. It will be noted also that the perforations in the inner shell terminate at a distance from the ends of the intermediate shell, so that a sound conducting passage is formed in which sound waves from the inner chambers 27 and 31 may pass into the outer chambers without interference by the sound waves of the interior of the inner shell.

It will be noted in Fig. 1, that the baffle in the space between the intermediate and outer shells is located so as to form resonating chambers of two different lengths. The location of the baffle 24 depends, of course, to a large extent upon the particular sounds which are to be muffled. The chambers 28, 29 and 30 are not in communication with either of the outer chambers, since it has been found desirable to provide some sound deadening chambers of this type. It is not, however, essential that only the end chambers communicate with the outer chambers, since equally good results can be obtained by establishing a sound conducting passage between any of the intermediate chambers, and an outer chamber.

It will be noted that in the muffler described, sound waves and gases pass lengthwise in the inner shell, in a circular or tangential direction in the inner chambers, and lengthwise of the muffler in the outer chambers. Furthermore, sound waves passing, for example, from the inner chamber 27 at substantially right angles to the direction of motion of the gases in the chamber 27, and also any sound waves returning from the outer chamber 25 through the neck or channel 34, enter the inner chamber 27 at right angles to the direction of travel of gases and sound waves in the chamber 27. This results in a very effective deformation of the sound waves, so that very effective silencing results.

In Figs. 4 and 5 is disclosed a slightly modified type of muffler which differs from the muffler shown in Fig. 1 mainly in that the intermediate shell is not bent inwardly at the ends thereof as shown in Fig. 1, but is of continuous cylindrical form. In this construction, the louvers in the inner shell terminate at a distance from the ends of the intermediate shell so that sound conducting passages or channels are formed between the inner and intermediate shells at the ends of these shells, through which channels sound and

gases can pass to the outer chambers 36 and 37 between the intermediate and outer shells. At the right end of the muffler shown in Fig. 4, the end of the intermediate shell is unsupported, and at the left end a supporting baffle 38 is provided, which preferably has apertures 39 therein through which sound waves may pass into the outer chamber 36. The operation of the muffler shown in Figs. 4 and 5 is identical with that shown in Figs. 1 and 3, and the same tangential motion of the gas as it leaves the inner shell and enters intermediate chambers is attained as before, and provision is made for sound waves and gases to leave and return to these chambers in a direction approximately at right angles to the directions of the tangential motions.

Figs. 6, 6a and 7 illustrate a muffler of the dumb-bell or sectional type, in which the muffler is constructed in three sections. The first section is provided with an inner shell 40, an intermediate shell 41, and an outer shell 42. Baffles 43, 44 and 45 divide the space between the inner and intermediate shells into two sound deadening chambers similar to those employed in connection with Figs. 1 to 5 inclusive. One end of the intermediate shell terminates at a distance from the end of this section of the muffler, and consequently, a portion of the perforations or louvers 18 of the inner shell will discharge gases into a chamber 46 formed between the inner shell and the outer shell of this section of the muffler, and a resonating chamber 47 is also formed between the imperforate intermediate shell and the outer shell. Sound waves and gases may travel into and out of this resonating chamber in a direction substantially perpendicular to the direction of movement of the gas in the chamber 46.

The gases discharged from the first section of the muffler enter into the second section which includes inner, intermediate and outer shells, the space between the inner and intermediate shells being divided into a series of chambers 48, 49 and 50, the chambers 49 and 50 having no communication with the outer chamber 51 of this section of the muffler. The chamber 48, however, communicates with the outer chamber 51 through the open end of the inner shell and through apertures 52 formed in a baffle 53. The apertures or louvers 18 of the inner shell terminate at a slight distance from the apertures 52 in the baffle 53 so as to form a sound-conducting passage connecting the chambers 48 and 51 for carrying only such sound waves to the outer chamber 51 as have been subjected to the action of the chamber 48.

The third section of the muffler is formed to produce inner chambers 55, 56 and 57 and outer chambers 58 and 59. At the discharge end of this section of the muffler, an enlarged chamber 60 is provided which extends from the inner shell to the outer shell of the muffler, and which communicates with the chamber 59 through holes 61 in a baffle or head 62, thus forming a sound absorbing chamber of a different shape to eliminate certain sound waves from the exhaust. In this case, gases entering the chamber 60 from the inner shell are given a motion tangential to the inner shell by passage through the louvers 18. Sound waves may pass laterally from the moving gases through the apertures 61 into the resonating chamber 59, and if any sound waves are deflected or returned by reflection from the baffle at the end of the chamber 59 to the body of gas in the chamber 60, such reflected or returned waves will strike the moving gases at substantial-

ly a right angle to their direction of movement, thus causing interference and modification of these sound waves in such a manner as to decrease the intensity of the sound waves.

It will be noted that the outer chamber 51 of the second section of the muffler is connected with the outer chamber 58 of the third section by means of a relatively small tube or passage 64. A single tube of this kind is shown connecting the two chambers, but more tubes may be employed, if desired. This connection between the two outer chambers has been found to produce results comparable to those obtained with a single chamber of greater length than that of either of the individual chambers or with proper size of connecting tube or tubes to results obtained with a single chamber of length equal to or greater than that of the combined length of the two chambers. This construction is, therefore, very desirable, particularly in cases where long mufflers are required to eliminate the sound waves from a particular engine, and where the under frames of the vehicle are so arranged that such long mufflers cannot be employed.

Various modified forms of sound-conducting passages, channels or necks for transmitting sound from one chamber of the muffler to another may, of course, be employed in connection with this invention. Another such passage of modified form is illustrated in Figs. 8 to 10 inclusive, in which the intermediate shell 67 is provided at its ends with inwardly indented or pressed portions 68 extending into contact with the inner shell 69. This arrangement provides relatively large sound conducting passages or necks 70, and if a still longer neck is required to produce the effective silencing of certain sound waves, a second intermediate shell or sleeve 72 may be employed which may be secured at one end to the outer head or baffle 73 of the muffler and spaced from the inner shell by means of a spacing member 74 and arranged in contact with the portions of the end of the intermediate shell 67, which are not indented or pressed inwardly, as clearly shown in Fig. 9. This arrangement, consequently, forms additional sound-conducting passages or necks 75 through which the sound passes in the passages 70 and enlarged spaces 76 are also provided between the intermediate shell 72 and the inner shell 69, in which the direction of travel of the sound waves and gases is reversed. In this construction, the sound waves and gases enter into the outer resonant chamber 77 intermediate of the ends thereof, and thus produce a silencing effect which is different from that resulting when the sound is admitted into an end of the resonant chamber.

In all of the constructions described, the mufflers develop very little back pressure, since the gases flow straight through the muffler from end to end thereof. Since each design of internal combustion engine develops sound waves in the exhaust which are different from another type of engine, it will, of course, be understood that mufflers of this type must be adjusted to suit the particular design of engine with which they are to be used. Consequently, the length of the muffler and the number of sound deadening chambers contained therein will vary materially, depending upon the nature of the engine with which the muffler is to be used, and the location of the baffles, as well as the diameters of the shells are also varied to produce the desired results. By providing the mufflers with neck portions connecting one muffling chamber with a second, such

second chamber with its entering neck portion provides a type of resonator which supplies destructive interference for sound waves in certain frequency bands as they attempt to pass through the muffler. The inner chambers arranged between the inner and intermediate shells are capable of eliminating very effectively certain sound waves. The muffler may be so tuned that destructive interference of sound waves in one frequency region will result from the action of chamber 25 while destructive interference in another frequency region will result from the action of chamber 27. The combination of these chambers provides means for eliminating sound waves or reducing their intensity over a considerable band of frequencies or in several different frequency regions. By making the chambers 31 and 26 of different lengths from the chambers 25 and 27, the two chambers 31 and 26 will cooperate with each other for the elimination of other sound waves, than those eliminated by the chambers 25 and 27. Furthermore, the chambers 29 and 30 being of different dimensions will each eliminate different sound waves, and if certain objectionable sound waves predominate in the exhaust and are difficult to eliminate, two similar chambers like the chambers 28 and 29 can be employed to eliminate such sound waves. This description of the operation of the construction shown in Figs. 1 to 3 applies equally well to the various types of sound reducing chambers employed in the other modified forms shown.

It will be noted that in all of the constructions illustrated, some of the chambers in which gas moves tangentially to the inner shell are connected with outer resonating chambers so that gases and sound waves pass from such a chamber to an outer resonating chamber, and this has been found to be very effective in silencing noises, particularly if the outer chamber communicates with the first chamber by means of a passage so arranged that the motion of gas and sound waves between the two chambers is substantially at right angles to the tangential motion of the gas as it enters the first chamber from the perforated inner shell. This method of silencing the exhaust has proven very effective and it appears that when sound waves travel in a moving gas, destructive interference of the sound waves takes place when the sound waves pass from a body of gas moving in one direction into a body of gas moving in another direction.

It has also been found advantageous to alternate the direction of rotation of the gases in different inner chambers by reversing the direction of the vanes or louvers in the inner shell, although this alternate arrangement of the louvers is not essential to the successful operation of the mufflers.

We claim as our invention:

1. A muffler having a substantially straight unobstructed passage therethrough for gases and sound waves, said passage having apertures therein, a chamber receiving gases and sound waves from said passage through said apertures, means for deflecting gases entering into said chamber in a direction substantially tangential with regard to said passage, and a second chamber having a reduced neck for receiving sound waves from said first chamber in a direction substantially perpendicular to said tangential direction, and having no direct communication with said passage, said reduced neck being of smaller cross sectional area than the cross sectional area of said first mentioned chamber.

2. A muffler having a shell provided throughout the greater part of the length thereof with perforations and having outwardly extending projections adjacent thereto, another shell arranged about said first mentioned shell, a transverse baffle connecting said shells, and an annular outwardly extending ridge on said first shell, the outer part of which extends outwardly at least as far as said projections and to which said baffle is secured, whereby said baffle may be passed lengthwise of said first mentioned shell over the projections thereon into engagement with said ridge.

3. A muffler having a shell provided throughout the greater part of the length thereof with a plurality of groups of perforations having outwardly projecting portions adjacent thereto, said shell having an annular unperforated portion, an outwardly projecting ridge on said annular unperforated portion, the outer portion of said ridge extending outwardly at least so far as said projections, and an annular transverse baffle having an internal diameter greater than the external diameter of said shell measured to the peaks of said projections, said baffle being secured to and forming a close fitting connection with said ridge.

4. A muffler having a shell provided throughout the greater part of the length thereof with a plurality of groups of perforations having outwardly projecting portions adjacent thereto, said shell having an annular unperforated portion provided with an outwardly pressed annular ridge formed in said shell, the outer surface of said ridge extending outwardly at least so far as said projections, and a transverse baffle secured to said outwardly extending ridge.

5. A muffler having an inner shell provided with a plurality of relatively small perforations, an outer imperforate shell having its ends closed, an intermediate shell, said inner and intermediate shells forming between them an inner chamber and said intermediate and outer shells forming between them an outer chamber, means cooperating with said perforations for deflecting gases discharged through said perforations in substantially tangential directions relatively to said inner shell, and a sound conducting passage of smaller cross sectional area than either of said chambers and connecting said inner and outer chambers and arranged in such angular relation to said tangential directions as to prevent the straight passage of sound waves from said passage to said perforations.

6. A muffler having an inner shell provided with a plurality of relatively small perforations arranged to discharge gases substantially tangentially of said inner shell, an outer imperforate shell having its ends closed, an intermediate shell, said inner and intermediate shells forming between them an inner chamber and said intermediate and outer shells forming between them an outer chamber, said inner chamber receiving gases and sound waves from said inner shell through said perforations, and a passage connecting said inner and outer chambers and of greater length than width in a radial direction and of less cross sectional area than said inner chamber and extending lengthwise of said muffler and receiving gases and sound waves only from an end of said inner chamber.

7. A muffler having spaced inner, intermediate and outer shells, said inner and intermediate shells forming between them an inner chamber and said intermediate and outer shells forming between them an outer chamber, louvers formed

on said inner shell for directing gases and sound waves into said inner chamber in a direction tangential to said inner shell, and a neck connecting said inner chamber and said outer chamber which extends substantially lengthwise of said muffler and which is of smaller cross sectional area than either of said chambers.

8. A muffler provided with a plurality of shells for providing a substantially straight inner passage for gases and inner and outer chambers surrounding said passage, said passage being provided with perforations through which gases and sound waves may pass from said passage to an inner chamber, means for discharging sound waves in a substantially tangential direction into said inner chamber, and a second passage leading from said inner chamber to said outer chamber and extending substantially in a direction parallel to the axis of said inner chamber and of smaller cross section than said inner chamber.

9. A muffler having an inner shell provided with a plurality of relatively small perforations, an outer imperforate shell, baffles connecting said inner and outer shells, an intermediate shell arranged between said inner and outer shells and between said baffles, an end of said intermediate shell having a portion pressed inwardly toward said inner shell to form a restricted passage for gases between said inner and intermediate shells, and a sleeve extending from a baffle over a part of said inwardly pressed portion of said intermediate shell to form between said sleeve and said inwardly pressed portion of said intermediate shell a return passage for gases.

10. A muffler including an inner perforate shell forming a passage for gases and sound waves through the muffler, an intermediate shell arranged about said inner shell and terminating short of the ends thereof, an outer shell arranged about said intermediate shell, heads closing the ends of said outer shell and provided with openings through which gases may pass to said inner shell, said inner shell having imperforate portions arranged adjacent to the ends of said intermediate shell, a baffle dividing the space between said intermediate and outer shells into resonance chambers, the ends of said intermediate shell about said imperforate portions of said inner shell being provided with inwardly pressed grooves, the inner surfaces of which are secured to said imperforate portions of said inner shell, said grooves being arranged between portions of said ends of said intermediate shell which are spaced from said imperforate portions of said inner shell to form channels leading to said resonance chambers, said channels being in communication with perforated portions of said inner shell to receive sound waves therefrom and conduct the same to said resonance chambers.

11. A muffler including an inner shell through which gases and sound waves pass, an outer shell and an intermediate shell extending about said inner shell, transversely extending members arranged between said intermediate and outer shells to form therewith a resonance chamber, said inner shell having an opening therein through which sound waves may pass into the space between said inner and intermediate shells, a longitudinally extending channel formed in a portion of said intermediate shell, and a sleeve extending around a portion of the channelled part of said intermediate shell to close portions of the outer open faces of said channels to form bottle necks communicating with said resonance chamber.

12. In a muffler, the combination of a shell forming a passage for gases through a muffler, a second shell arranged about said first shell, an outer shell arranged about both of said shells and forming with said second shell a resonator chamber, said first shell having an opening through which sound waves may pass into the space between said first and second shells, an end of said second shell having a longitudinally extending channel formed therein, a sleeve arranged about portions of said first shell and the channelled end of said second shell, said channelled portion forming with said inner shell a passage of lesser cross section than the space between said first and second shells and forming with said sleeve a continuing passage between said second shell and said sleeve.

13. In a muffler, the combination of a shell forming a passage for gases through a muffler, a second shell arranged about said first shell, an outer shell arranged about both of said shells and forming with said second shell a resonator chamber, said first shell having an opening through which sound waves may pass into the space between said first and second shells, an end of said second shell having a longitudinally extending channel formed therein, the bottoms of said channels engaging said first shell, a sleeve arranged about a part of the channelled portion of said second shell, said channelled portion forming with said first shell a restricted passage for sound waves which connects with a restricted passage formed by said channelled portion and said sleeve, said latter restricted passage terminating in said resonance chamber.

14. In a muffler, the combination of a shell forming a passage for gases through a muffler, a second shell arranged about said first shell, an outer shell arranged about both of said shells, a head connecting said outer shell with said first shell, said second shell terminating at a distance from said head, said first shell having an opening through which sound waves may pass from the interior thereof into the space between said first and second shells, the end of said second shell adjacent to said head being provided with a longitudinally extending channel, and a sleeve secured to said head and extending about said channelled end of said second shell, whereby a restricted passage is formed between said first and second shells and which connects with a passage formed between said sleeve and said second shell and terminating in the space between said outer and second shells.

15. In a muffler, the combination of a shell forming a passage for gases through a muffler, a second shell arranged about said first shell, an outer shell arranged about both of said shells, a head connecting said outer shell with said first shell, said second shell terminating at a distance from said head, said first shell having an opening through which sound waves may pass from the interior thereof into the space between said first and second shells, and an imperforate portion adjacent to said head, and a sleeve secured to said head and extending about the end portion of said second shell, whereby a restricted passage is formed between said imperforate portion of said first shell and the end portion of said second shell, which passage connects with a passage formed between said sleeve and said second shell and terminating in a space exterior to said second shell.

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