March 17, 1936. L. R. HEATH 2,034,186

MUFFLER

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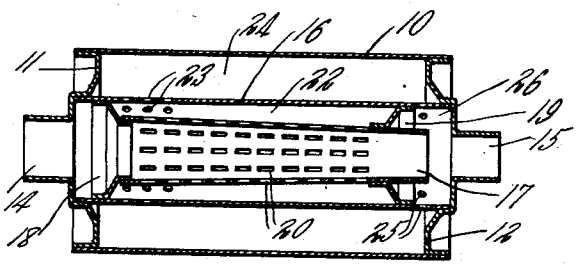


Fig. 1

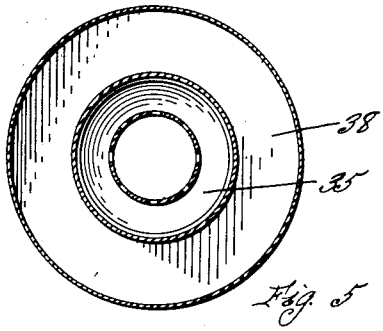


Fig. 5

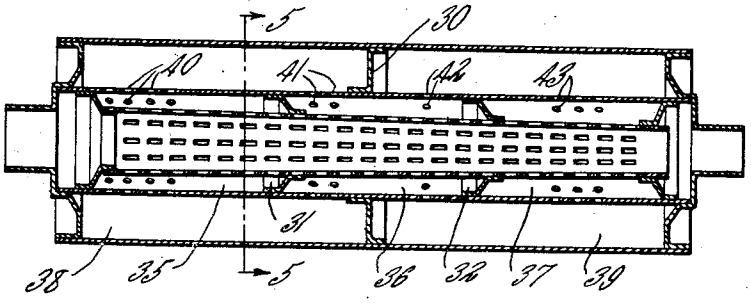


Fig. 2

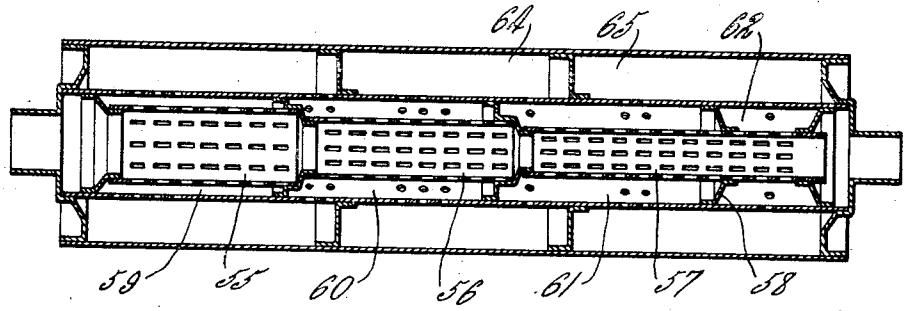


Fig. 4

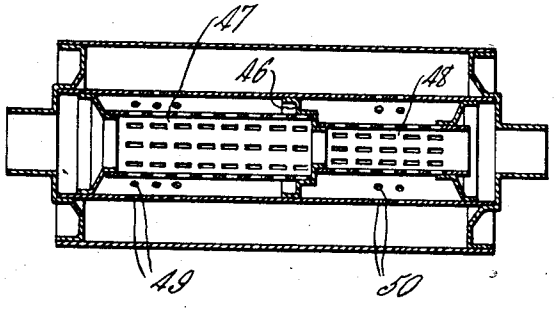


Fig. 3

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2,034,186

MUFFLER

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13 Claims. (Cl. 137—160)

This invention relates to improvements in mufflers of the type commonly employed for silencing noises resulting from the discharge of exhaust gases from an internal combustion engine.

The objects of this invention are to provide a muffler of this kind of improved construction, by means of which the back pressure caused by the muffler is materially less than in mufflers heretofore commonly employed; also to provide a muffler of this kind in which the pulsations in the pressure and flow of exhaust gases are reduced to such an extent that a substantially uniform or only slightly pulsating flow of exhaust gas is discharged from the muffler; also to provide a muffler of this kind in which the pulsating gases entering the muffler are permitted to expand in certain chambers formed about the muffler and to again join the current of gas going through the muffler during low pressure intervals or between the pulsations; also to provide a muffler of this kind in which noise due to the exhaust is reduced by producing a substantially uniform flow of exhaust gas through the discharge passage of the muffler; also to produce a muffler of this kind in which the chambers surrounding the inner passage through the muffler are designed to permit gases to flow back and forth into and out of the chambers in accordance with the pulsations of the gas in the inner passage, and also to cause some gas to flow through the chambers from the inlet to the discharge of the muffler; also to improve mufflers of this kind in other respects hereinafter specified.

I have found that when a muffler is designed in such a manner as to smooth out the pulsating flow of the exhaust gases from an internal combustion engine, such a muffler will at the same time remove the objectionable exhaust noises. Even the simplest types of mufflers of the kind heretofore employed will transmit very little of the initial sound of the exhaust of an engine, but in such mufflers the waves of gases leaving the mufflers create noises or sounds which are objectionable. In accordance with my invention, I, therefore, reduce the intensity of the pulsations of the exhaust gases, and I have found that when a muffler is designed to remove these pressure or flow pulsations from the exhaust gases, the objectionable noise of the exhaust is also eliminated. The mufflers shown in the accompanying drawing are, therefore, designed to remove the crests from the impulse waves of exhaust gases entering the muffler and to employ the gas from these crests to fill up subsequent troughs or low pressure spaces between these waves, thus producing a flow of gas at the discharge end of the muffler which has very little variation in pressure. I have also accomplished this result by producing a muffler having a passage extending straight through the same so that the gases passing through the muffler encounter a minimum resistance to flow and, consequently, result in very little back pressure.

In the accompanying drawing, I have illustrated some forms of mufflers capable of producing the desired results, but it will be understood that the mufflers shown in the drawing are merely illustrative, since wide variations in the numbers of baffles and in the passage of gases through shells may be made in order to accommodate mufflers to engines of different kinds. In this drawing:

Fig. 1 represents a longitudinal sectional elevation of a muffler embodying this invention.

Figs. 2, 3 and 4 are similar sectional elevations of mufflers of modified constructions.

Fig. 5 is a transverse sectional elevation on line 5—5, Fig. 2.

Fig. 1 embodies the simplest form of my invention and in this form, the muffler is provided with an outer shell 10 having heads 11 and 12 secured to the ends thereof, the head 11 at the inlet side of the muffler being provided with a tubular extension 14 constituting the inlet of the muffler and with which the exhaust pipe from the engine may connect, and the head 12 at the discharge end of the muffler being formed with a tubular extension 15 to which a tail pipe may be secured. The heads 11 and 12 may also be provided with shoulders with which an intermediate shell 16 engages. The muffler also has an inner shell or conduit 17 which may be suitably mounted on the muffler in any desired manner, and which, in the construction shown, is supported on the inner shell by means of baffles 18 and 19. Any other means for supporting the shells and heads relatively to each other may be provided.

In accordance with my invention, the inner tube or shell 17 is preferably constructed to pass the flow of exhaust gas therethrough, and the discharge end of this tube or shell may be made slightly smaller than the inlet opening. In the particular construction shown in Fig. 1, this result is obtained by constructing the inner shell so that the same tapers slightly from the receiving end thereof to the discharge end. This causes the gases entering the muffler from the inlet opening therein to build up a pressure near the inlet end of the inner shell 17 which is slightly greater than the pressure at the discharge end of this shell.

In accordance with my invention, this shell is made of perforated metal substantially throughout the length thereof. The perforations may be of any suitable or desired form, but I have found that if the perforations are formed as rectangular slits 20 extending lengthwise of the inner shell, the most satisfactory results are

obtained, and that a whistling sound which sometimes results if perforations of circular shape are used, does not occur. While such rectangular perforations are preferably employed, it will be understood that perforations of any other form may be used, since the object of these perforations is mainly to permit gases to pass out of the inner shell through these perforations into a chamber 22 formed between the inner and intermediate shells of the muffler. In the construction illustrated in Fig. 1, apertures 23 are formed in the intermediate shell near the inlet end of the muffler so that gases may pass through these apertures 23 into the outer chamber 24 of the muffler which is arranged between the intermediate and outer shells thereof. The intermediate shell is provided with a second series of apertures or openings 25 which, in the particular constructions shown, are arranged in rear of the baffle 19, and the discharge end of the inner shell terminates at a distance from the discharge duct 15 of the muffler so that the discharge end of the shell 17 has an ejector action which tends to draw gases through the apertures 25 to mix with the gases discharged from the inner shell, and thus to enter into the tail pipe of the muffler. The discharge end of the inner shell extending beyond the baffle 19 is preferably not perforated, to increase the ejector action.

In the operation of this muffler, when a charge of exhaust gas enters into the inner shell 17 thereof, as a result of the opening of an exhaust valve of the engine, the pressure wave or pulsation of this gas will have a relatively high peak caused by the gas leaving the engine at considerable pressure immediately after the opening of the exhaust valve. This wave or pulsation of exhaust gas entering into the inner shell 17 will, of course, tend to expand as rapidly as possible and upon reaching the inner shell, this gas will immediately expand through the perforations 20 therein and enter into the inner chamber 22. Because of the high pressure peak, some of the gas entering the chamber 22 will immediately flow through the apertures 23 into the outer chamber 24. Immediately after the peak of the wave, there will be a depression in the wave or pulsation, so that gases in the chambers 22 and 24 will again tend to flow in the reverse direction through the apertures 22 of the inner shell 17, thus adding this amount of gas to the trough or depression of the pulsation. It will be evident, therefore, that by removing the peak of a wave or pulsation of exhaust gas and again returning the gas of the peak thus removed into the trough, both the peak and the depression or trough of the wave or pulsation have been removed, so that when this exhaust gas finally enters the tail pipe, it will flow at a fairly uniform rate and with greatly reduced variation in pressure between the peak and the trough of the wave of exhaust gas. This uniform flow or discharge of the gas from the tail pipe into the air, consequently, takes place without the objectionable noises which result when a less uniform flow of gas is discharged, or in other words, when gas is discharged with widely varying pressures and rates of flow.

The gas entering the muffler is, of course, hot and in entering the chamber 24, it becomes materially cooled by contact with the relatively cool outer shell 16 of the muffler, the outer surface of which contacts with the outside air. It will be noted also that the apertures 23 in the intermediate shell are more numerous than the apertures 25, and consequently, between pulsations in the flow of gas in the inner shell, some of the gas from the outer chamber 24 will be drawn back through the apertures 23 and through perforations 20 into the current of gas flowing in the inner shell 17. The same action also occurs when cool gas is drawn through the apertures 25 by the ejector action of the discharge pipe 17 into a second intermediate chamber 26. These cool gases mixing with the hot gases discharged from the inner shell also have a silencing effect upon sound waves in the muffler because of the refraction of these sound waves in passing through gases of different temperatures.

It will be understood that the apertures 25, which, in the construction shown, are arranged in rear of the baffle 19, may be located in front of this baffle, in which case, the ejector action will be replaced by a drawing of gas through these apertures due to the fact that the pressure of gas at the discharge end of the inner shell 17, due to the taper of this shell, is less than at the inlet end thereof. In either case, cool gas will flow crosswise of the inner shell resulting in the well known silencing effect upon sound waves.

The operation of this muffler is believed to be as follows: When a wave or pulsation of gas enters into the inlet end, gas flows rapidly out through the perforations in the inner shell into the intermediate space or chamber of the muffler located between the inner and intermediate shells, and a portion of this gas flows through the apertures 23 into the outer chamber of the muffler. Immediately reduction of the pressure in the inner shell results, and when the pressure wave or pulsation reaches the discharge end of the muffler, its pressure is so reduced that no objectionable sound results when this pulsation is discharged from the end of the tail pipe. A considerable portion of the gas from the intermediate and outer shells will flow back into the inner shell when the peak of the pressure wave has passed and will then pass outwardly through the tail pipe in a comparatively steady or uniform flow, and without producing objectionable noise. By this construction, the flow of gas from the inner shell during the peak or high pressure portion of the pressure wave, reduces or flattens out this peak and materially reduces the pressure in the inner shell, and when the trough or portion of low pressure of the wave passes into the inner shell, this gas in the intermediate and outer chambers is returned and fills in this trough, with the result that a fairly uniform discharge of gas takes place through the discharge end of the muffler.

In addition to this alternating movement of gas in the chambers of this muffler, there will also be a movement in the outer chamber toward the discharge end of the muffler, this movement being produced by the ejector action of the discharge end of the muffler, resulting in the mixing of gases of different temperatures, which has been described. Probably a similar movement of gas takes place in the inner chamber because of the fact that the pressure in the inner shell is greater at the inlet end thereof than at the discharge end. This passage of gas lengthwise of the muffler through the chambers surrounding the inner shell has a further equalizing effect on the gas discharged from the muffler, and also reduces back pressure by cooling the gases by contact with the outer shell, thus reducing

the volume of the gas to be discharged. The resulting mixture of gases of varying temperatures results in a turbulence and refraction and absorption of sound waves. Furthermore, by maintaining a flow of gases through the several chambers, a deposit and accumulation of other foreign material in the chambers is prevented. The chambers also act as traps for sound waves.

The converging or tapering inner shell also acts as an inverted megaphone in that it reduces the intensity and length of sound waves passing through it.

Referring to Fig. 2, the construction illustrated is quite similar to that shown in Fig. 1, except that in this case, the muffler is larger and of greater capacity, and a baffle **30** is provided between the outer and intermediate shells intermediate of the heads of the muffler, and a pair of baffles **31** and **32** are provided between the inner and intermediate shells and spaced at intervals. This arrangement of the baffles **31** and **32** results in the formation of chambers **35**, **36** and **37** between the inner and intermediate shells, and the baffle **30** results in the formation of outer chambers **38** and **39** between the outer and intermediate shells. The intermediate shell is provided near the inlet end of the muffler with a plurality of apertures **40** through which gases passing through the perforations of the inner shell into the chamber **35** may pass into the chamber **38**, and additional perforations **41**, fewer in number than the perforations **40**, establish communication between the chamber **38** and the chamber **36**. Similarly a relatively small number of perforations **42** are provided in the intermediate shell between the baffles **30** and **32** to establish communication between the chamber **36** and the chamber **39**, and a larger number of perforations or apertures **43** are formed to establish communication between the chambers **39** and **37**.

In the operation of this muffler, gas from the peaks of the pulsations passes out through the perforations of the inner shell and successively enters the chambers **35**, **36** and **37**. Gases from the chamber **35** may pass through apertures **40** into the outer chamber **38**, and when the trough of the pressure wave is reached, a part of these gases may again pass in the reverse direction through the openings **40** and perforations in the inner shell. Other gases from the outer chamber **38** will pass into the intermediate chamber **36** through the apertures **41**, it being borne in mind that the pressures along the tapered inner shell vary, being highest at the inlet end of the muffler and lowest at the discharge end. Gases from the chamber **36** may also pass outwardly through the apertures **42** into the chamber **39**, and then through apertures **43** into the chamber **37**, and thence back to the inner shell. In this case, the inner shell does not have the ejector action described in connection with Fig. 1, but by slight rearrangement of the baffle supporting the discharge end of the inner shell from the intermediate shell and the apertures **43**, the muffler can be readily changed to produce the ejector action, if the same is desired.

In the construction shown in Fig. 2, in addition to the effect of producing an even flow of gas through the muffler, the chamber **36** has a decided silencing action on sound waves because of the fact that hot and cold gases flow into and out of this chamber and set up a turbulence in this chamber, which has been found to deaden sound. The muffler shown in Fig. 2 is of considerably larger capacity than the one shown in Fig. 1, and because of the plurality of chambers provided lengthwise of the inner shell, a greater equalization of pressure is produced by this muffler, than by the one shown in Fig. 1, which greater equalization would be necessary in connection with larger engines because of greater pressure variations of the exhaust gases. It will be obvious that the number of chambers in a muffler can be readily varied as desired by increasing or decreasing the number of baffles and the length of the shells, but preferably the chambers are so arranged that the gases passing lengthwise through the chambers about the inner shell will pass alternately from an intermediate chamber to an outer chamber and from such outer chamber to another intermediate chamber located nearer to the discharge end of the muffler. This reversal of directions or alternate inward and outward flow of gases helps materially in eliminating sound waves from the gases discharged by the muffler. It will, of course, be understood that dead chambers, or chambers into and out of which gases flow only through the same set of openings may be used, if desired, in connection with the interconnected chambers.

Fig. 3 shows a muffler which is quite similar to the one shown in Fig. 1, except that in Fig. 3 the inner sleeve is formed of two parts of different diameters, the part of the smaller diameter being nearer the discharge end of the muffler, and the two parts being held in place by shoulders formed on an intermediate head **46**. The portion **47** of the inner shell or tube is of larger diameter than the portion **48**, so that there will be a slightly greater pressure at the inlet end of the muffler than at the discharge end. The intermediate head **46** divides the chamber between the inner and intermediate shells into two intermediate chambers, and a similar intermediate head could, of course, be employed on the muffler shown in Fig. 1. This arrangement causes gases to pass from one of these chambers through apertures **49** into the outer chamber between the outer and intermediate shells and then through apertures **50** from the outer chamber into the other intermediate chamber, and finally back to the inner shell.

It will be noted that in all of the constructions shown, none of the chambers formed in the muffler are dead chambers, since there is a circulation or flow of gas in each chamber. This prevents the collection of water or other material in the chambers, and thus adds greatly to the life of the muffler in preventing corrosion or rusting of the same, and maintains the efficiency of the muffler at its highest point throughout its life by preventing the filling up of any chamber with liquid, soot, or other foreign material. This muffler can be readily changed to produce the ejector action by arranging the apertures **50** and the baffle which supports the discharge end of the inner shell in the manner shown in Fig. 1, this change also being possible with the other constructions herein illustrated.

The construction shown in Fig. 4 is intended for use where a materially greater amount of silencing is required, than can be obtained from the use of the muffler shown in Figs. 1 and 3, and in this case, the inner shell comprises three sections or parts **55**, **56** and **57**, which are of successively smaller diameters, and thus produce a stepped arrangement in the inner shell which may be used interchangeably with the tapering shells shown in Figs. 1 and 2. Baffles are pro-

vided between the inner and intermediate shells at the ends of the several sections or parts of the inner shell, and an additional baffle 58 is provided intermediate of the ends of the section 57 of the inner shell. Baffles are also provided between the intermediate and the outer shells and arranged alternately with baffles between the inner and intermediate shells. This forms intermediate chambers or compartments 59, 60, 61 and 62 between the inner and intermediate shells, and outer chambers 63, 64 and 65 between the intermediate and outer shells. The apertures in the intermediate shell are so arranged that gases may pass from the intermediate chamber 59 into the outer chamber 63 and through this chamber 63 into the intermediate chamber 60. In the chamber 60, the gases may flow either into the intermediate shell or into the chamber 64 and gases cooled in the outer chamber 63 will mix with the hot gases entering through the perforations of the portion 56 of the inner shell, and thus produce the turbulence referred to in connection with the description of Fig. 2. The presence of gases of different temperatures in different parts of the chamber 60 produces refraction and absorption of sound waves. Gases from the chamber 64 enter into the chamber 61, and consequently, turbulence is again set up in this chamber with the result of further deadening of sound waves. Some gases from the chamber 61 will enter into the outer chamber 65, and thus into a chamber 62, this flow being induced by the decreased pressure at the discharge end of the inner shell, or if desired, the baffle and apertures at the discharge end of the intermediate shell may be rearranged as shown in Fig. 1, to produce an ejector action.

It will be understood in connection with all of these mufflers which have been described, that the flow of gases through the chambers about the inner shell is not necessarily continuous in a direction from the receiving to the discharge end of the muffler, since this flow varies with variations in pressure in the inner shell. For example, when the peak of a pressure or pulsation wave of exhaust gas reaches the inner shell, there will be a very rapid flow of gas from the perforations of the inner shell and a corresponding flow into the chamber between the intermediate and outer shells. When the peak has passed, there will be greater pressure in the chambers surrounding the inner shell than in the inner shell, and consequently, there will be an immediate return of the gases from the chambers to the inner shell. By the time the trough of the wave or pulsation is reached, the larger volumes of gas temporarily stored in the outer chambers of the muffler will reach the inner shell, the return of these gases to the inner shell being delayed because of the greater distance which they have to travel. In this manner, the impulse or gas pressure waves will be to a very large extent smoothed out by the action of the chambers of the muffler, and consequently, a much more uniform flow of gas will discharge from the tail pipe, and consequently, objectionable noises ordinarily caused by the discharge of gases from the end of the tail pipe into the atmosphere will be eliminated. In addition to the alternating flow of gases into and out of the chambers, there will be a more or less constant flow through these chambers in the general direction toward the discharge end of the muffler, which flow results in the drawing of the cooled gases back into the inner shell for mixture with the hot gases and for producing the refraction and absorption of sound waves in this shell. Without this continuous flow, the cooled gases in the outer chambers would not be mixed to any appreciable extent with the gases in the inner shell, since these cooled gases would act more or less as buffers or cushions in the outer chambers without actually passing out of these chambers. The passing of gases through the chambers about the inner shell also reduces the volume of gases which must pass through the inner shell and, consequently, reduces back pressure in the muffler. I have found it particularly effective in silencing the exhaust to provide imperforate baffles and passing the gases in opposite directions into and out of an outer chamber through apertures in the inner shell.

It will be understood that the constructions shown in the drawing are merely illustrative of the principle of my invention and numerous changes in the details of construction may be made. While the best results are obtained when the inner shell is of lesser diameter at its discharge end than at its receiving end, yet I have found that in certain cases good results can be obtained if the inner shell is of uniform diameter throughout, if other means are employed for slightly reducing the pressure near the discharge end of the muffler.

I claim as my invention:

1. A muffler having inlet and outlet openings, an inner perforate shell extending from said inlet toward said outlet opening, intermediate and outer shells arranged concentrically about said inner shell, baffles connecting said inner and intermediate shells and dividing the space between said inner and intermediate shells into a plurality of turbulence chambers, a baffle extending from said intermediate to said outer shell at a point between said first mentioned baffles, and dividing the space between said intermediate and outer shells into separate cooling chambers, passages in said intermediate shell connecting different zones of each cooling chamber with different turbulence chambers and each intermediate turbulence chamber with both cooling chambers whereby gases may enter each cooling chamber from one turbulence chamber and then pass directly into another turbulence chamber and by turbulence of hot and cooled gases within each turbulence chamber refract sound waves and lessen the intensity of sounds emitted by the muffler.

2. A muffler including inner, intermediate, and outer shells, the inner shell being perforate and forming a substantially direct passage through said muffler, said inner and intermediate shells forming between them an inner chamber, the perforations in said inner shell establishing communication between the interior thereof and said inner chamber, an outer chamber formed between said intermediate and outer shells, and substantially imperforate baffles disposed crosswise of said shells and subdividing the inner chamber into separate turbulence chambers and said outer chamber into cooling compartments, said intermediate shell being perforate solely in limited minor zones, with the perforations connecting each outer cooling compartment through one of said zones with one of said turbulence chambers and through another of said zones with another of said turbulence chambers, said perforations also connecting one of said turbulence chambers with both of said cooling compartments whereby gases may enter each cooling compartment from

one turbulence chamber and after being cooled therein pass into another turbulence chamber.

3. A muffler including inner, intermediate and outer shells, said inner shell being perforate and forming a substantially direct passage for gases through said muffler, and being formed of portions of varying diameters, the portions of said inner shell nearer to the discharge end of said muffler being of less diameter than the portion near the gas receiving end of said inner shell, said intermediate and inner shells forming between them a sound eliminating chamber, a plurality of imperforate, transverse baffle means disposed across said chamber at intervals along its length and subdividing it into turbulence chambers, the space between said intermediate and outer shells forming a cooling chamber, imperforate partition means disposed across said cooling chamber at a point between two of said baffle means to subdivide said cooling chamber into compartments, said intermediate shell having a perforate zone connecting one end portion of each compartment to one turbulence chamber and another perforate zone connecting the other end portion of that compartment to another turbulence chamber, said intermediate shell being otherwise substantially imperforate.

4. A muffler including an inner shell and intermediate and outer shells arranged about said inner shell, the space between the intermediate and outer shells forming a cooling chamber, means cooperating with said shells to divide the space between said inner and intermediate shells into a plurality of non-communicating intermediate chambers, imperforate means disposed transversely across said cooling chamber and dividing it into compartments disposed end to end, said inner shell communicating directly with each of said intermediate chambers, and passages in said intermediate shell solely in zones thereof spaced substantially apart lengthwise of that shell for connecting each cooling compartment at different zones thereof directly with two adjacent intermediate chambers, one of which intermediate chambers is connected to both of said compartments, said passages having an aggregate area which is very materially less than the area of communication between said inner shell and said intermediate chambers.

5. A muffler having inlet and discharge openings in opposite ends thereof, an inner shell open at its opposite ends and extending substantially from the inlet to the discharge opening of said muffler, said shell being provided with perforations substantially throughout the length thereof and being of smaller diameter at the discharge end thereof than at the inlet end, intermediate and outer shells arranged in spaced relation to each other about said inner shell, means for closing the ends of the spaces between said inner, intermediate and outer shells, imperforate baffles arranged between said inner and intermediate shells and forming a plurality of intermediate chambers disposed end to end, an imperforate wall arranged between and connecting the intermediate and outer shells at a point between two intermediate baffles in a direction along the length of the shells and dividing the space between said intermediate and outer shells into outer chambers disposed end to end, each outer chamber being arranged in overlapped relation to the two adjacent intermediate chambers, and perforations in said intermediate shell to establish communication of each outer chamber with the two adjacent intermediate chambers, one of said intermediate chambers establishing communication between the two outer chambers separately from the passage through the inner shell.

6. A muffler having inlet and outlet openings, an inner perforate shell extending from said inlet toward said outlet opening, intermediate and outer shells arranged concentrically about said inner shell, a plurality of substantially imperforate baffles connecting said inner and intermediate shells and dividing the space between said inner and intermediate shells into a plurality of chambers, a substantially imperforate wall extending from said intermediate to said outer shell at a point between two of said baffles, and dividing the space between said intermediate and outer shells into separate compartments having no direct communication with one another, said intermediate shell being apertured solely in relatively small zones spaced apart along the length of said intermediate shell but with said zones at opposite sides of each of said baffles connecting said inner and intermediate shells and connecting each intermediate chamber directly with two different and adjacent compartments, and each compartment with two different and adjacent chambers.

7. A muffler including inner, intermediate, and outer shells, the inner shell being perforate and forming a substantially direct passage through said muffler, said inner and intermediate shells forming between them an inner chamber, the perforations in said inner shell establishing communication between the interior thereof and said inner chamber, separate and non-communicating outer compartments formed between said intermediate and outer shells and disposed in a row along the length of said outer shell, and substantially imperforate baffles disposed crosswise of said inner and intermediate shells, each at a point between the ends of an adjacent compartment, and subdividing said inner chamber into separate non-communicating sub-chambers, each overlapping with an adjacent compartment, said intermediate shell being perforate solely in limited minor zones spaced apart in a direction endwise of the shells, with each outer compartment communicating directly through one of said zones with one of the inner sub-chambers, and through another of said zones with another of said sub-chambers, and with each sub-chamber between the end sub-chambers communicating directly with a plurality of adjacent compartments, the total areas of the perforations in the zone of the intermediate shell leading to one inner sub-chamber from one compartment being less than for the zone leading from the same compartment into another inner sub-chamber.

8. A muffler for internal combustion engines and the like comprising a casing subdivided by imperforate walls into a direct passage therethrough from end to end, and a plurality of separate chambers, one group of said chambers being disposed along and communicating directly and freely with said direct passage, but having substantially no direct communication with one another, and another group of said chambers being disposed along the chambers of said one group and having substantially no direct communication with one another, each of the chambers of said another group having restricted direct communication with two different chambers of said one group, and at least one chamber of said one group having direct communication separately of the other chambers of that group and of said passage, with a plurality of the chambers of said

another group, whereby the chambers of said another group may all communicate with one another through the chambers of said one group, so as to provide for restricted and local communication between chambers of said one group by means of a chamber of said another group.

9. A muffler for internal combustion engines and the like comprising a casing subdivided by imperforate walls into a direct passage therethrough from end to end, and a plurality of separate chambers, one group of said chambers being disposed along and communicating directly and freely with said direct passage, but having substantially no direct communication with one another, and another group of said chambers being disposed along the chambers of said one group and having substantially no direct communication with one another, each of the chambers of said another group having restricted direct communication with two different chambers of said one group, and at least one chamber of said one group having direct communication separately of the other chambers of that group and of said passage, with a plurality of the chambers of said another group, whereby the chambers of said another group may all communicate with one another through the chambers of said one group, so as to provide for restricted and local communication between chambers of said one group by means of a chamber of said another group, some of the chambers of said one group having different volumes.

10. A muffler for internal combustion engines and the like comprising a casing subdivided by imperforate walls into a direct passage therethrough from end to end, and a plurality of separate chambers, one group of said chambers being disposed in a row along and communicating directly and freely with said direct passage, but having substantially no direct communication with one another, and another group of said chambers being disposed along the chambers of said one group and having substantially no direct communication with one another, each of the chambers of said another group having restricted communication, solely at zones spaced substantially apart in a direction lengthwise of said direct passage, with two chambers of said one group, and each intermediate chamber in said row of said one group having restricted communication with two of the chambers of said another group solely at said zones, so as to provide for restricted and local communication between chambers of said one group by means of a chamber of said another group.

11. A muffler for internal combustion engines and the like comprising a casing subdivided by imperforate walls into a direct passage therethrough from end to end, and a plurality of separate chambers, one group of said chambers being disposed in a row along and communicating directly and freely with said direct passage, but having substantially no direct communication with one another, and another group of said chambers being disposed in a row along the chambers of said one group and having substantially no direct communication with one another, each of the chambers of said another group having restricted communication, solely at zones spaced substantially apart in a direction lengthwise of said direct passage, with two chambers of said one group, and each intermediate chamber in said row of said one group having restricted communication with two of the chambers of said another group solely at said zones, so as to provide for restricted and local communication between chambers of said one group by means of a chamber of said another group, the aggregate areas of communication between each chamber of said another group with the chambers of said one group, being greater at the zone nearer the inlet end of said direct passage than at the other zone of the same chamber of said another group.

12. A muffler having inlet and outlet openings, an inner perforate shell extending from said inlet toward said outlet opening, intermediate and outer shells arranged concentrically about said inner shell, baffles connecting said inner and intermediate shells and dividing the space between said inner and intermediate shells into a plurality of chambers, a wall extending from said intermediate to said outer shell, approximately midway between the two nearest baffles and dividing the space between said intermediate and outer shells into separate chambers, perforations in said intermediate shell at opposite sides of each of said baffles connecting said inner and intermediate shells, at least one of said inner chambers between said inner and intermediate shells receiving cool gases from one of said outer chambers and discharging gases to said other outer chamber through said perforations in said intermediate shell, and also being arranged to receive hot gases through the perforations of said inner shell, to set up a turbulence of gases within said intermediate chamber to refract sound waves.

13. A muffler including inner, intermediate and outer shells, said inner shell being perforate and forming a substantially direct passage for gases through said muffler, and being formed of portions of varying diameters, the portion of said inner shell nearer to the discharge end of said muffler being of less diameter than the portion near the gas receiving end of said inner shell, said intermediate and inner shells forming between them a sound eliminating chamber, imperforate, transverse baffle means across said chamber and subdividing it into turbulence chambers disposed end to end along said passage, the space between said intermediate and outer shells forming a cooling chamber, an imperforate wall connecting the outer and intermediate shells at a point intermediate said baffle means and dividing said cooling chamber into compartments disposed end to end lengthwise along said shells, with each compartment overlapping with a common turbulence chamber with which the other compartment overlaps, said intermediate shell having perforate zones to provide communication from said common turbulence chamber to both of said compartments and from the other turbulence chambers to the other overlapping compartments, said intermediate shell being otherwise substantially imperforate, the perforate zones of said intermediate shell having a less aggregate perforate area than the aggregate perforate areas of the section of said passage through those turbulence chambers, and the aggregate perforate area of the zone connecting said common chamber to the compartment nearest the gas inlet end of said passage being greater than for the zone connecting said common chamber to the other compartment, substantially all of the gases from said chambers being returned to said inner shell for discharge from said muffler.

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