March 14, 1939. G. C. STARKWEATHER ET AL 2,150,811

MUFFLER

Filed March 10, 1937 3 Sheets-Sheet 1

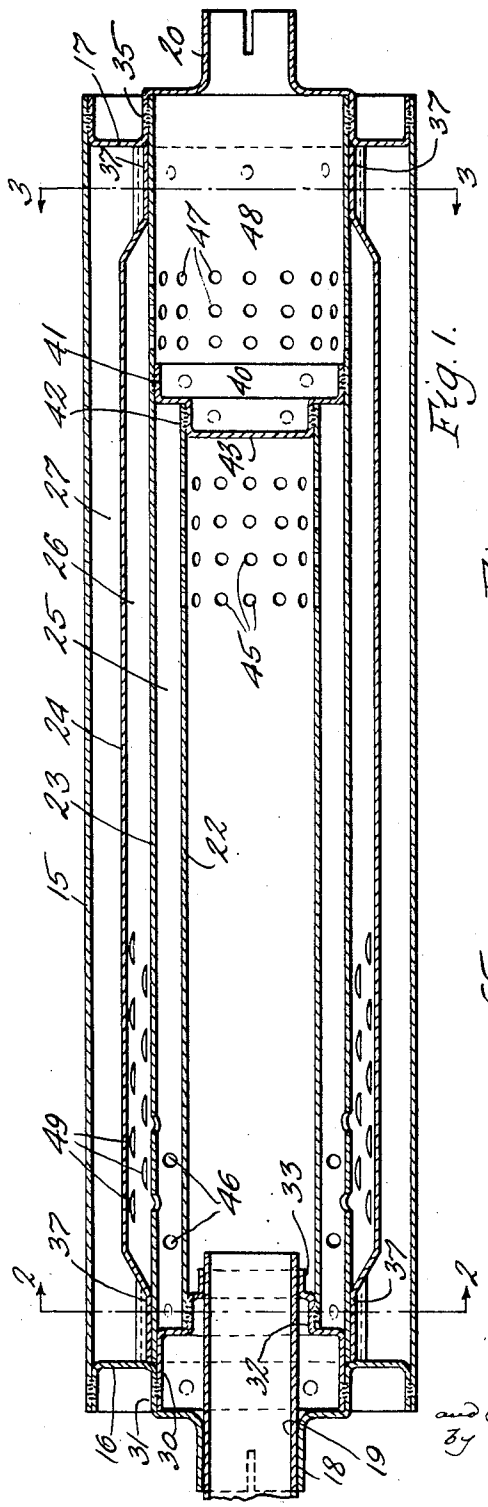


Fig. 1.

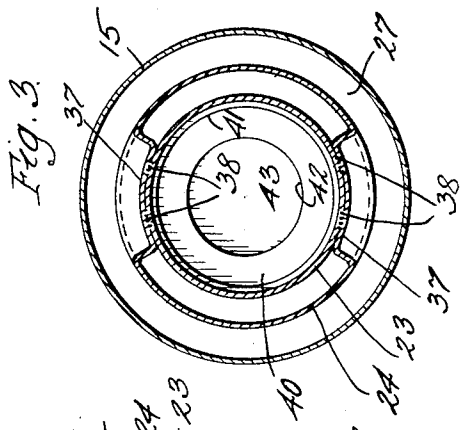


Fig. 3.

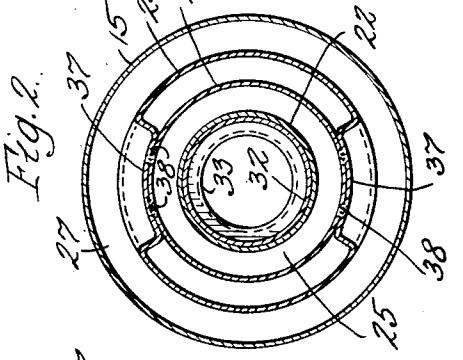


Fig. 2.

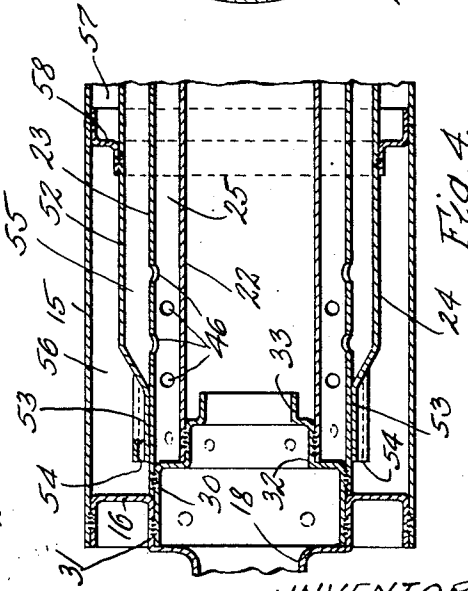


Fig. 4.

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Filed March 10, 1937 3 Sheets-sheet 2

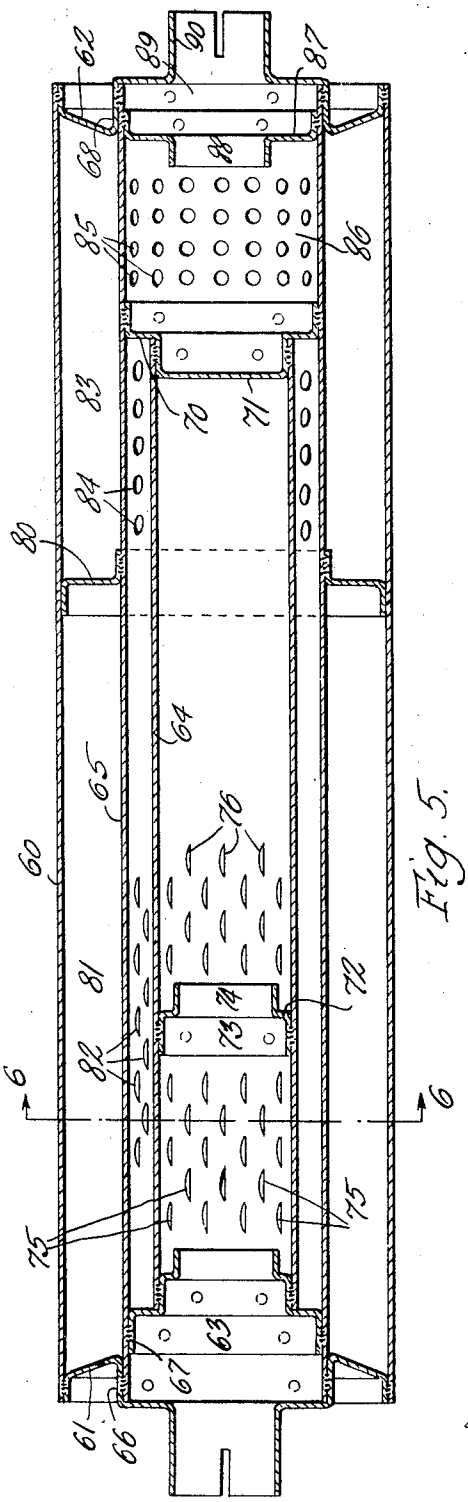


Fig. 5.

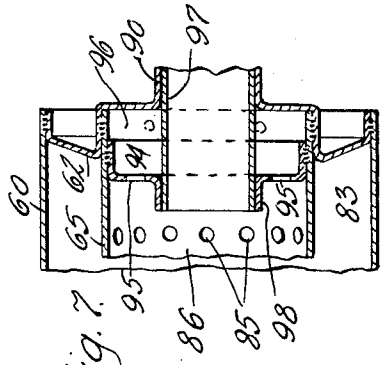


Fig. 7.

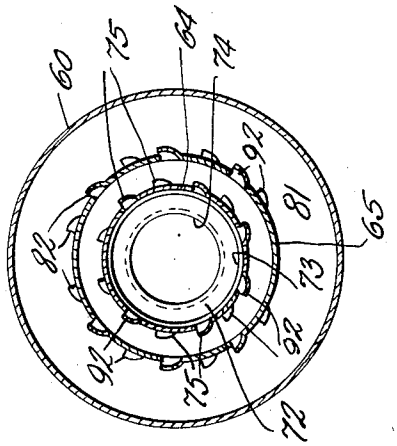


Fig. 6.

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Filed March 10, 1937 3 Sheets-Sheet 3

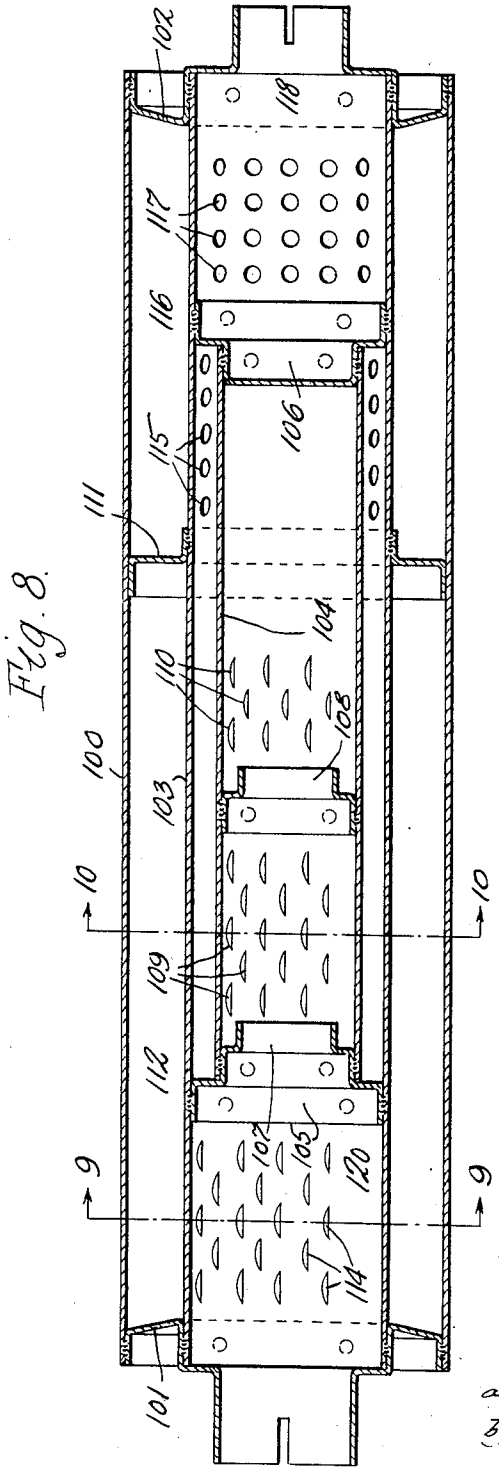


Fig. 8.

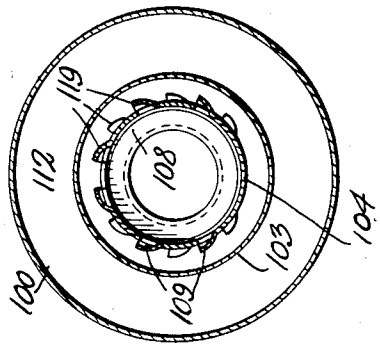


Fig. 10.

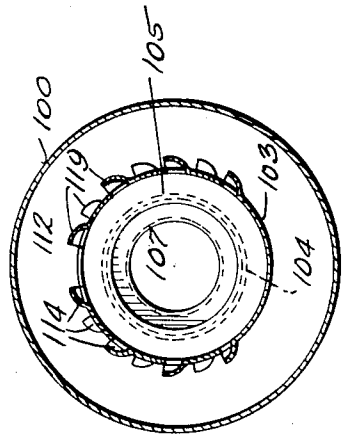


Fig. 9.

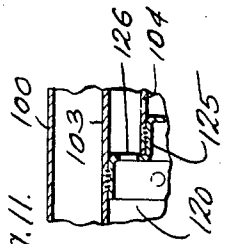


Fig. 11.

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UNITED STATES PATENT OFFICE

2,150,811

MUFFLER

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Application March 10, 1937, Serial No. 130,158

8 Claims. (Cl. 181—55)

This invention relates to improvements in mufflers or silencers for use in silencing the noises of the exhaust of an internal combustion engine.

One of the objects of this invention is to provide an improved muffler of the type in which the gases are caused by baffles or the like to change their direction of flow while passing through the muffler, with a resonator chamber.

Another object of the invention is to provide a muffler of this type in which a chamber is provided into which surges or peaks of pressure waves may pass to provide a more uniform flow of gases through other parts of the muffler.

Another object of the invention is to provide a muffler of this type with a resonator chamber which acts upon the sound waves to reduce noise by destructive interference.

Other objects of this invention will appear from the following description and claims.

In the accompanying drawings:

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

Figs. 2 and 3 are transverse sections thereof respectively on lines 2—2 and 3—3, Fig. 1.

Fig. 4 is a fragmentary longitudinal sectional elevation of one end of a muffler of slightly modified construction.

Fig. 5 is a longitudinal central sectional view of a muffler of modified construction.

Fig. 6 is a transverse sectional view thereof, on line 6—6, Fig. 5.

Fig. 7 is a fragmentary longitudinal central sectional view of one end of the muffler shown in Fig. 5, with a slight modification.

Fig. 8 is a longitudinal central sectional view of a muffler of still another modified construction.

Figs. 9 and 10 are transverse sectional views respectively on lines 9—9 and 10—10, Fig. 8.

Fig. 11 is a fragmentary longitudinal central sectional view of a portion of the muffler shown in Fig. 8, with a slight modification.

We have found that if a muffler of the type in which the gases in passing through the same are caused by baffles, shells or the like, to change their direction of flow a number of times, is provided with a resonator chamber, superior results can be obtained not only insofar as the silencing of sound waves is concerned, but also in that the resistance to the flow of gases through the muffler will be reduced by the use of such resonator chamber which acts as an equalizing chamber for the pressure impulses, so that the back pressure heretofore produced by mufflers of this type is reduced.

We have illustrated by way of example several forms of mufflers of this type embodying our invention and it will be understood that the mufflers shown are merely illustrative of our invention and that it is not intended to limit this invention to the particular constructions shown.

In Fig. 1, a muffler is shown having a suitable housing or enclosure which may, for example, include an outer shell 15 and end heads 16 and 17. The head 16 is provided with a tubular extension or duct 18 adapted to receive an exhaust pipe 19 and the other head 17 is provided with a similar duct or tubular portion 20 through which the gases are discharged from the muffler and to which the usual tail pipe (not shown) may be secured. The muffler includes an inner shell or conduit 22 and a pair of intermediate shells 23 and 24, which are spaced from each other and from the conduit 22 and outer shell 15 to form spaces or chambers 25, 26 and 27.

The conduit and shells may be supported within the muffler in any suitable or desired manner. In the particular construction shown, a stepped cone or supporting member is provided which has a substantially cylindrical outer portion 30 adapted to fit within an annular cylindrical part 31 of the inlet head 16. This cylindrical part 30 of the shell support also is arranged to telescope within the adjacent end of the intermediate shell 23 to support the same. The shell support has another cylindrical portion or shoulder 32 of smaller diameter which is adapted to telescope within the adjacent end of the inner conduit 22. The shell support may, if desired, be provided with an additional cylindrical portion 33 of still smaller diameter which extends into the conduit 22 and which may receive the inner end of the exhaust pipe 19 as shown in Fig. 1. At the other end of the muffler, the discharge head 17 is provided with a cylindrical portion or shoulder 35 within which the shell 23 may fit. The other intermediate shell 24 of larger diameter may be supported in the muffler in any suitable manner, for example, by providing the opposite ends thereof with inwardly pressed projections or parts 37 which rest against and which may be welded to the intermediate shell 23 as indicated at 38. Any other means for securing the shells in correct relation to each other and to the muffler may, of course, be employed in place of those shown, and the connecting or telescoping parts of shells, heads, baffles and shell supports may be welded together or otherwise secured, or may be left to slide relatively to each other to compen-

sate for expanison and contraction due to unequal heating of different parts of the muffler during use.

The other or rear end of the conduit 22 may be supported in correct relation to the inner shell by means of a baffle 40 having an outer cylindrical portion 41 which may be welded or otherwise secured to the shell 23 and having a second cylindrical portion 42 of smaller diameter which may telescope into the other end of the conduit 22. This baffle includes a transverse wall 43 which closes the rear end of the inner conduit 22.

The inner conduit is provided with a discharge opening, which may be in the form of a series of apertures 45 through which the gases may flow from the inner shell 22 into the chamber 25 between this conduit and the intermediate shell 23. The intermediate shell 23 is provided with an opening or apertures 46, preferably located at a distance from the apertures 45 of the conduit 22, for example, near the inlet head 16 of the muffler, and the gases and sound waves may, consequently, be discharged through these apertures from the chamber 25 into the chamber 26. The intermediate shell 23 near the discharge end of the muffler and beyond the baffle 40 is provided with a series of apertures 47 through which the gases flow from the chamber 26 into the chamber 48 formed at the rear end of the shell 23 between the baffle 40 and the head 17. The intermediate shell 24 is also provided with means for communicating with the outer chamber 27 of the muffler and any suitable means for this purpose may be employed, such for example as a series of apertures 49.

In the operation of the muffler, the exhaust gases from the engine are discharged through the exhaust pipe 19 into the inner conduit or shell 22 in the form of a series of pressure pulsations or waves, which are accompanied with sound waves. The gases pass to near the end of the shell 22 and are then discharged through the apertures 45 into the chamber 25, from which they pass through the apertures 46 into the chamber 26. During the crest or peak of a pressure wave, some of the gases pass into the chamber 26 through the apertures 49 into the outer or resonator chamber 27. After a pressure peak has passed out of the chamber 26, some of the accumulated gas in the resonator and equalizing chamber 27 is discharged back into the chamber 26. Sound waves also pass through these apertures 49 into the resonator and equalizing chamber and then back through the same aperture into the chamber 26, at which time they will be out of phase with similar sound waves in the chamber 26. The gases and any remaining or modified sound waves then continue to flow lengthwise into the chamber 26 through the apertures 47 in the chamber 48 from which they are discharged from the muffler.

The resonator chamber 27 in addition to its silencing effect upon the sound waves, thus also serves a very useful purpose of equalizing the flow of gases so that when a surge of gas enters the chamber 26, following the opening of an exhaust valve, a portion of this gas will enter into the chamber 27 and will again be discharged into the chamber 26 during the trough of the pressure wave or impulse. This results in a steady flow of gas through the passage or chamber 26 and through the apertures 47, chamber 48, and through the tail pipe. This steady flow results in a material reduction in the resistance to the flow, and consequently, results in a reduction in the back pressure of the muffler, as well as producing a very excellent silencing of the exhaust noises.

In Fig. 4 is shown an end of a muffler similar to the one shown in Figs. 1 to 3 inclusive, except for the following changes: The muffler shown in Fig. 4 has a second intermediate shell 52 corresponding to the shell 24 of the muffler shown in Figs. 1 to 3. The ends of the shell 52 are also provided with depressions or inwardly pressed portions 53 corresponding to the parts 37 of the shell 24, forming portions or channels 54. The muffler shown in Fig. 4 differs from that shown in Figs. 1 to 3 in that the end of the shell 52 is spaced from the head 16, so that the channels 54 are utilized to carry the gases and sound waves from the chamber 55 formed between the two intermediate shells 23 and 52 into the outer resonance chamber 56 formed between the outer shell 15 and the intermediate shell 52. The channels 54 consequently, form bottle necks for the resonator chamber 56, and the wave lengths to which the chambers respond can be varied by changing the cross section and length of the bottle necks. In connection with this construction, it is also possible to divide the outer space between the shells 52 and 15 into two resonator chambers 56 and 57 by means of an annular transverse baffle 58. This baffle can, consequently, be moved lengthwise of the space between the shells 15 and 52 so that the chamber 56 may be tuned in accordance with the particular sound waves which it is desired to silence by destructive interference. Obviously, if two resonator chambers are desired, the opposite end of the intermediate shell 52 may be similarly formed to communicate with the chamber 57. The operation of this muffler is similar to that of the muffler shown in Figs. 1 to 3.

The modified form of our invention shown in Figs. 5 and 6, includes an outer shell 60 which with the heads 61 and 62 forms an enclosure or housing for the muffler. The heads shown are similar in construction to those described in connection with the mufflers shown in Figs. 1 to 4, to form tubular extensions or ducts for connection with exhaust and tail pipes. The muffler is also provided with a supporting member 63 in the form of a stepped cone to which an inner shell or conduit 64 is secured. In this construction, however, only one intermediate shell 65 is employed which is suitably welded or otherwise secured to a cylindrical shoulder or part 66 of the inlet head 61, and the supporting member 63 has an outer cylindrical portion 67 welded or otherwise secured to the inner face of the intermediate shell 65. The other end of the intermediate shell may be telescopically arranged within a substantially cylindrical shoulder 68 of the head 62 and welded thereto.

The end of the inner shell or conduit remote from the gas receiving end is closed and supported from the intermediate shell 65 by means of a baffle member 70, the outer flange or portion of which may be welded to the intermediate shell 65 and the middle portion 71 of which telescopes within the end of the inner conduit. The inner conduit may also be provided with a restriction or contracting member which may be in the form of a sleeve 72 having an outer substantially cylindrical portion 73 welded to the inner face of the conduit 64 and having an annular portion 74 of reduced diameter. A restriction or obstruction to gas flow of any other suitable construction may be employed in the conduit 64, or the restriction may be omitted, if desired.

The space between the intermediate shell 65 and the outer shell 60 is separated into two chambers by means of an annular baffle 80, thus forming a resonator and pressure equalizing chamber 81 which communicates with the space between the conduit 64 and intermediate shell by means of a series of holes or apertures 82 in the intermediate shell 65. At the other side of the baffle 80 is formed a chamber or passage 83 which receives gases from the space between the conduit and intermediate shell through a series of apertures 84 in the intermediate shell located in front of the baffle 70 and the gases and sound waves pass out of the chamber 83 through another series of holes or apertures 85 located in rear of the baffle 70. The gases thus pass into a chamber 86 arranged within the intermediate shell between the baffle 70 and a transverse baffle 87 having a restricted opening 88 which may form a support for the inner end of the tail pipe, or which may form with the end head 62 a small expansion chamber 89 in case the tail pipe does not extend inwardly beyond the inner end of the tubular extension or duct 90 of the head 62.

Holes or apertures 75, 76 and 82 in the inner conduit and intermediate shell may, if desired, be provided with louvers or deflecting members 92, as clearly shown in Fig. 6, so that the gases and sound waves discharged through these apertures will be discharged in directions substantially tangential to the conduit and shell in which the apertures are formed.

In Fig. 7, we have illustrated a slight modification of the construction shown in Fig. 5, by replacing the baffle 88 shown in Fig. 5 by a baffle 94 which has a series of apertures 95 therein. Consequently, a chamber 96 is formed between the baffle 94 and the end head 62, which serves as an expansion chamber, if the tail pipe 97 of the muffler extends from the duct 90 into the central opening 98 of the baffle 94.

In the operation of the muffler shown in Figs. 5 to 7, some of the gases and sound waves passing into the inner conduit 64, will discharge through openings 75 therein while other gases pass through the restriction 74 and then through openings 76 and these gas pulsations and sound waves will, consequently, be somewhat out of phase with those that have passed through the openings 75. A further silencing of sound waves and equalizing of gas flow results from the passage of sound waves and gases into the resonator chamber 81. Peaks of gas pressure waves or impulses which enter into the chamber 81 are then discharged from this chamber during the troughs or low pressure periods, resulting in a more uniform flow of gases through the apertures 64, the chamber 83 and into the chamber 86. From the chamber 86 further expansion of gases and silencing of sound waves is effected by means of the chambers 89 or 96, and consequently, there will be a comparatively uniform flow of exhaust gases through the tail pipe 97. The sound waves which have passed into the muffler will have been so interfered with and reduced by the resonator chamber 81 and other parts of the muffler that the gas discharged from the end of the tail pipe will be comparatively free from audible sound waves.

In Figs. 8 to 10 inclusive, we have shown another modified form of muffler, which is very similar to that shown in Figs. 5 to 7. This muffler includes an outer shell 100 and end heads 101, 102, which are provided with annular shoulders to support the ends of an intermediate shell 103. The inner shell or conduit 104 is supported within the intermediate shell 103 by means of baffles 105 and 106, the baffle 106 closing the end of the inner conduit or shell 104 and the baffle 105 being provided with an aperture 107 which is preferably of smaller diameter than the internal diameter of the conduit 104. The inner shell or conduit 104 is also provided with a restriction or contraction 108 similar to that described in connection with Figs. 5 and 6 and acting in a similar manner in connection with apertures 109 and 110 located before and behind the restriction 108. An annular baffle 111 is provided between the intermediate and outer shells forming a resonator and expansion chamber 112 into which gases and sound waves may enter through a series of apertures 114 which are formed in the intermediate shell ahead of the baffle 105. The intermediate shell is also provided with apertures 115 communicating with a chamber 116 formed in rear of the annular baffle 111 and the gases and sound waves pass out of the chamber 116 through a series of openings or apertures 117 into a chamber 118 from which they are discharged from the muffler. The apertures 109, 110 and 114 may be provided with louvers or deflecting parts 119, as shown in Figs. 9 and 10.

In the operation of this muffler, gases and sound waves entering the muffler through the inlet head 101 enter into the expansion chamber 120 and the peaks or crests of pressure impulses or waves, together with sound waves immediately enter through the apertures 114 into the resonator and pressure equalizing chamber 112. The reduced pressure waves or impulses together with sound waves which have been materially reduced by destructive interference from sound waves discharged from the resonator chamber 112 then pass into the conduit 104, the reduced opening 107 of the baffle 105 serving to hold back to a limited extent the gases and sound waves in the chamber 120 to obtain the full benefit of the resonator and equalizing chamber 112. A part of the gas pressure impulses and sound waves pass out of the openings 109 and other gas impulses and sound waves will pass out of apertures 110 after travelling through the restriction 108, and will be somewhat out of phase with those discharged from the apertures 109. This results in an equalizing of the flow of gases as they pass through the apertures 115 and also in a material reduction of noises, first by the resonator chamber 112 and then by the action of the other parts of the muffler which have been described. Further equalizing of pressure impulses and reduction of sound waves takes place in the chambers 116 and 118.

In Fig. 11, there is shown a baffle 125 arranged between the intermediate shell 103 and the inner shell or conduit 104, which differs from the baffle 105 only in that there are provided in the transverse wall of the outer portion of the baffle a series of apertures 126, through which some gas and sound waves may pass directly from the chamber 120 into the chamber or passage formed between the inner conduit 104 and the intermediate shell 103. For certain types of engines, these apertures assist materially in taking out sound waves of certain frequencies in that there will be discharged into the space between the inner conduit and intermediate shell some gas impulses and sound waves, which will be out of phase with impulses and sound waves entering through the apertures 109 and 110.

The restrictions in the inner conduit also act,

in the case of gas pressure impulses, to build up a pressure in the portion of the conduit ahead of the restrictions before a pressure is built up in the part of the conduit in rear of the restriction, so that an outward flow through perforations or openings ahead of the restriction takes place before a flow through perforations or openings in rear of the restriction can take place. In this manner, the flow of gases through the muffler is also equalized, and since sound waves follow the flow of gases, interference of sound waves also results for this reason.

We claim as our invention:

1. A muffler including an outer shell, heads closing the ends of said shell, one of said heads having an opening for receiving gases and sound waves, and the other head having a discharge opening, an intermediate shell connecting said heads and spaced from said outer shell, and an inner shell concentrically arranged within said intermediate shell and having one end arranged to receive gases and having the other end closed and being provided with apertures through which gases may flow into the space between said inner and intermediate shells, a transverse partition arranged intermediate the ends of said intermediate shell and separating one part thereof from another and also extending across said inner shell in rear of said apertures therein and forming the closure for said closed end of said inner shell, said intermediate shell having two sets of apertures, one located in advance of said partition and the other located in rear of said partition, means forming a concentric passage about said intermediate shell and connecting said apertures of said intermediate shell for conducting gases exteriorly of said intermediate shell from one set of apertures to the other, said outer shell and said intermediate shell forming between them a resonator chamber communicating with the interior of said intermediate shell for receiving pressure pulsations therefrom without forming a part of the flow passage of gases through said muffler.

2. A muffler including a perforate inner shell forming a passage for receiving gases at one end thereof and having the other end thereof closed, a pair of intermediate shells arranged about said inner shell and spaced therefrom and from each other to form passages for gases between said shells, the inner of said intermediate shells receiving gases from perforations in said inner shell and forming with said inner shell a longitudinal passage for gases and having an apertured zone spaced in a longitudinal direction from the perforations of said inner shell and through which gases flow from said passage between said inner shell and the inner of said intermediate shells into the space between said intermediate shells and having other apertures through which gases are discharged from said space, and an outer shell arranged about said intermediate shells and forming therewith a resonator chamber communicating with the passage between said intermediate shells and arranged exterior to the path of gases flowing through the muffler.

3. A muffler including an outer shell, heads closing the ends of said shell, one of said heads having an opening for receiving gases and sound waves, and the other head having a discharge opening, an intermediate shell connecting said heads and spaced from said outer shell, and an inner shell arranged within said intermediate shell and having one end arranged to receive gases and having the other end closed and being provided with apertures through which gases may flow into the space between said inner and intermediate shells, a transverse baffle dividing the space between said outer and intermediate shells into a resonator chamber and flow passage, said intermediate shell having apertures through which gases may enter and leave said resonator chamber and other apertures through which gases may pass from the space between said inner and intermediate shells into said flow passage, and a transverse baffle extending across said intermediate shell and arranged rearwardly of said apertures in said intermediate shell, said intermediate shell also having apertures rearwardly of said baffle through which gases flow from said flow passage to the interior of said intermediate shell for discharge from said muffler.

4. A muffler including an outer shell, heads closing the ends of said shell, one of said heads having an opening for receiving gases and sound waves, and the other head having a discharge opening, an intermediate shell connecting said heads and spaced from said outer shell and forming therewith a resonator chamber, said intermediate shell having apertures adjacent to said gas receiving head and communicating with said resonator chamber, an inner shell arranged within said intermediate shell with its leading end open and disposed in rear of said apertures and arranged to receive gases from said intermediate shell and having the other end closed and having two sets of apertures through which gases may flow out of said inner shell after their passage into said inner shell from said intermediate shell, a restriction in said inner shell arranged with one set of said apertures arranged ahead of said restriction and with other set of apertures arranged in rear of said restriction, and means in said muffler for conducting out of the muffler gases discharged from said inner shell.

5. A muffler including an outer shell, a head closing an end of said shell and having an opening into which a gas conducting pipe may extend, a second shell arranged within said outer shell, and a support for said securing second shell to the muffler adjacent to said head and having an aperture therein spaced from said head and into which the inner end of said gas conducting pipe fits snugly to provide two spaced supports for said pipe.

6. A muffler including an outer shell, a head closing an end of said shell and having an opening into which a gas conducting pipe may extend, a second shell arranged within said outer shell, and a supporting member for said second shell, which is supported on said muffler from said head and which extends into the interior of said muffler into spaced relation to said head, said supporting member including an annular shoulder engaging said shell and an opening of substantially the same diameter as the opening in said head and in alinement therewith and into which the inner end of said pipe may extend to produce a rigid connection between said pipe and said muffler.

7. A muffler including a series of shells arranged one within another and forming between them spaces for the passage of gases and sound waves, the inner of said shells being arranged to receive gases at one end thereof and having the other end thereof closed and having a restricted perforate zone to permit gases to discharge into the space between said inner shell and the next shell, said next shell having a set of apertures spaced lengthwise from the perforations of said inner shell and disposed in advance of the closed

end of said inner shell, through which gases pass after passing lengthwise of the space between said inner and said next shell, said next shell also having another set of apertures in rear of the closed end of said inner shell through which gases pass into the interior of said next shell for discharge from said muffler, a transverse partition arranged in said next shell between said sets of apertures, and a side branch resonator chamber formed by some of said shells and connected with a gas passage of said muffler.

8. A muffler including an outer shell, heads closing the ends of said shell, one of said heads having an opening for receiving gases and sound waves, and the other head having a discharge opening, an intermediate shell connecting said heads and spaced from said outer shell and forming therewith a resonator chamber, said intermediate shell having apertures adjacent to said gas receiving head and communicating with said resonator chamber, an inner gas receiving shell arranged within said intermediate shell with its inlet end disposed in rear of said apertures and arranged to receive gases from said intermediate shell and having the other end closed and having apertures through which gases may flow out of said inner shell, and means in said muffler for conducting out of the muffler gases discharged from said inner shell.

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