

[54] EXPANSION TYPE SILENCER

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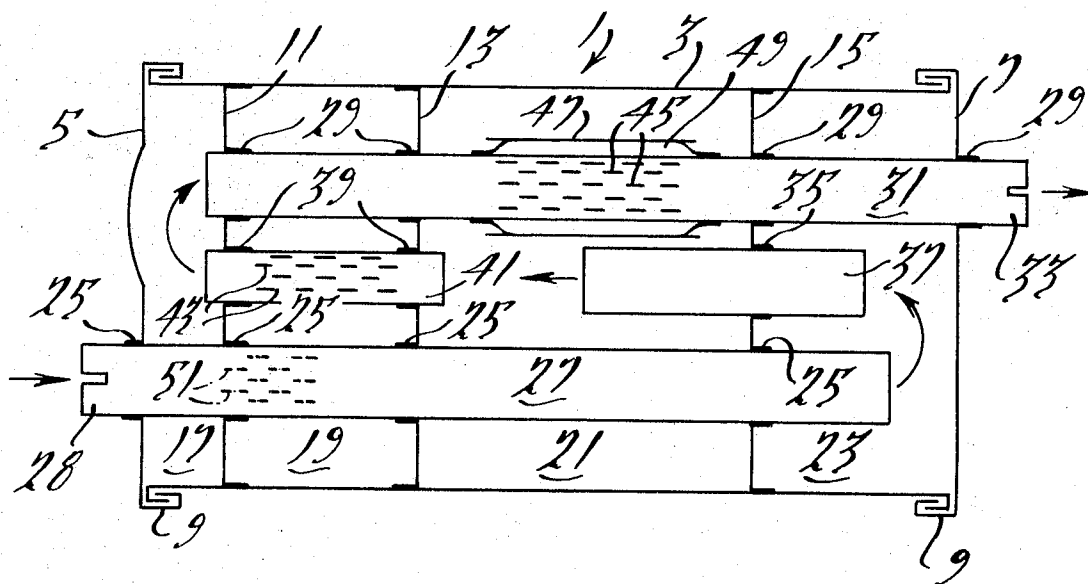
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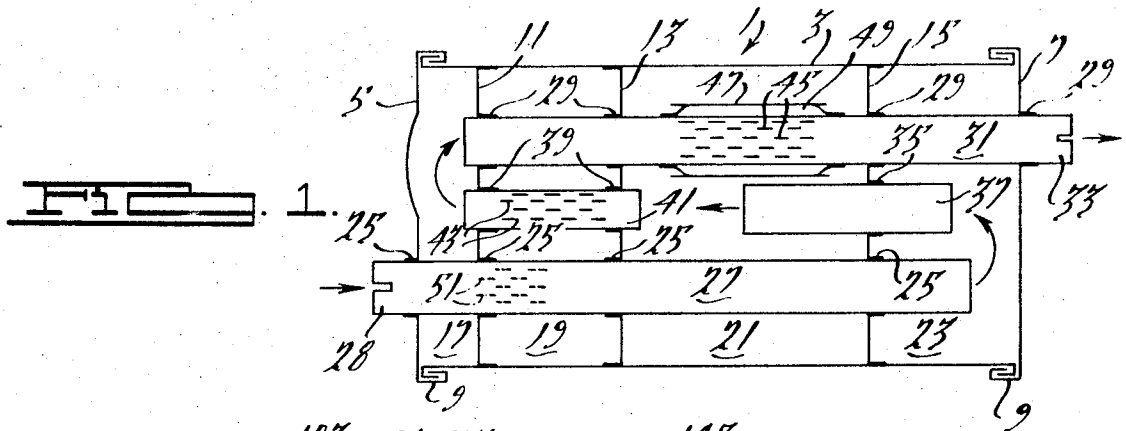
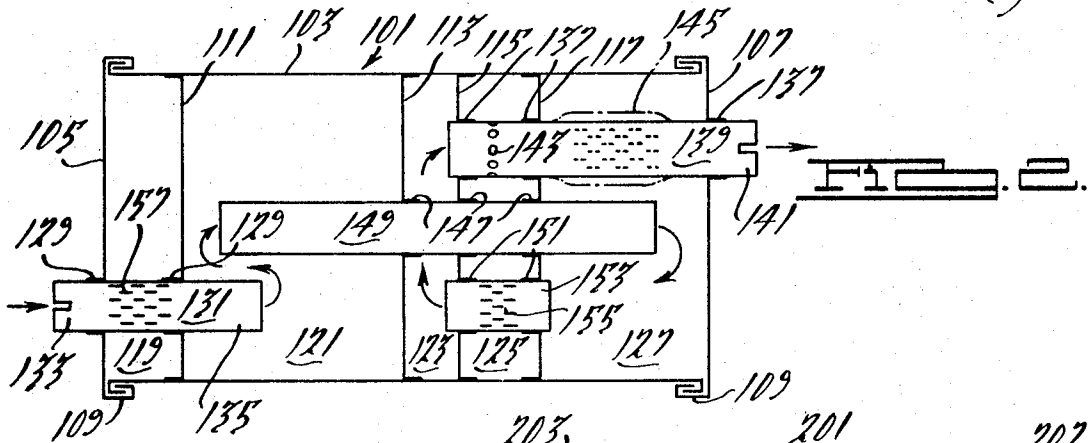
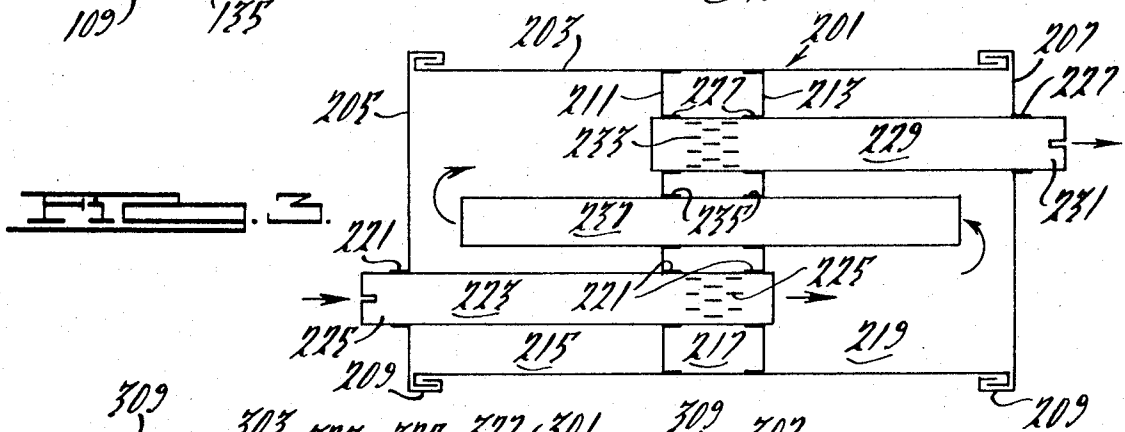
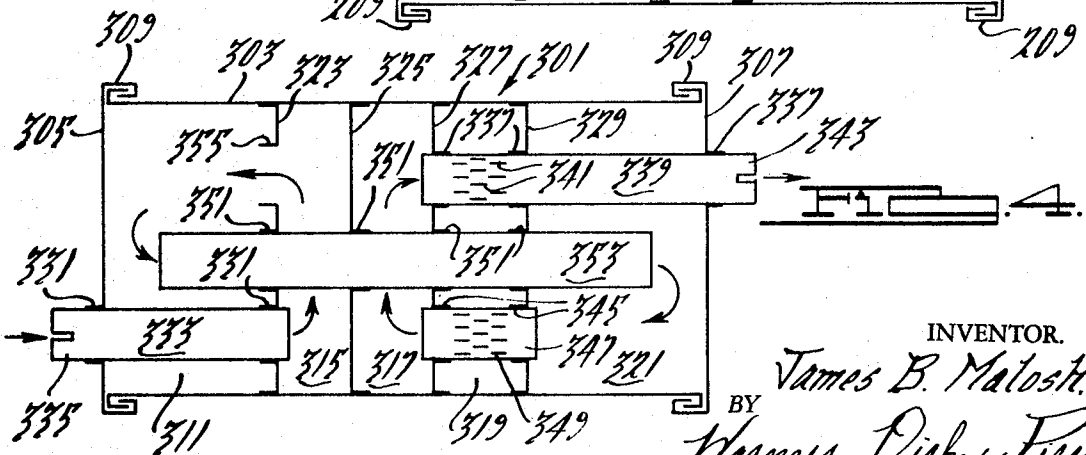
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[57] ABSTRACT

A retroverted or tri-flow type muffler for use in internal combustion engine exhaust systems has inlet and outlet tubes and a pair of expansion chambers interposed in the gas path between the tubes, the chambers being interconnected by an intermediate imperforate tube which together with the two chambers is tuned to attenuate a broad band of frequencies.

13 Claims, 4 Drawing Figures





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EXPANSION TYPE SILENCER

BRIEF SUMMARY OF THE INVENTION

It is the purpose of the invention to provide a muffler usable in internal combustion engine exhaust systems to attenuate sound across a broad range of frequencies from low to high.

The invention achieves this purpose by means of a muffler providing tri-flow or retroverted flow gas path wherein medium and high frequency attenuating means are preferably used in the inlet and outlet portions of the gas path and a double expansion chamber with connecting tube construction is preferably used in an intermediate portion of the gas path.

DESCRIPTION OF THE DRAWING

Each of the figures in the drawing is a longitudinal cross section through a muffler embodying a form of the invention in which the muffler is preferably oval in cross section and wherein thickness of metal used to form the muffler and its component parts is shown as a single thickness line and in which:

FIG. 1 is a longitudinal cross section through a first form of the invention;

FIG. 2 is a longitudinal cross section through a second form of the invention;

FIG. 3 is a longitudinal cross section through a muffler embodying a third form of the invention; and

FIG. 4 is a longitudinal cross section through a muffler embodying a fourth form of the invention.

DESCRIPTION OF THE INVENTION

In FIG. 1 the muffler 1 has an outer shell 3, preferably of oval tubular shape, which is closed at its inlet end by a header 5 and at its outlet end by a header 7, the outer edge of the header and the ends of the shell being interconnected in rolled gas-tight joints 9.

A series of transverse partitions 11, 13, and 15 extend across the width of the shell 3 and are longitudinally separated from each other to form four longitudinally separated chambers 17, 19, 21, and 23. The outer edge of each partition is shaped and secured to the inner surface of the shell 3 in a known manner (e.g., spotwelding) so as to fix the partitions in place. The inlet header 5 and the partitions 11, 13, and 15 have aligned necks 25 which provide apertures that telescopically receive an inlet tube 27, with an outer end 28 forming an inlet bushing, that serves to carry gases from the connection of the muffler with an exhaust pipe (not shown) over most of the length of muffler to discharge them into the chamber 23. The outlet header 7 and the partitions 11, 13, and 15 have aligned necks 29 which provide openings that telescopically receive an outlet tube 31 that receives gases from end chamber 17 and carries them through most of the length of the muffler to discharge them into a tailpipe (not shown) which may be connected to the projecting end or bushing section 33 of the tube 31.

The partition 15 has an annular neck 35 which receives and supports a tube 37 that has a predetermined imperforate (i.e., effective) length and which is open on each end to connect the chamber 23 to the chamber 21. The partitions 11 and 13 have aligned necks 39 which provide openings to telescopically receive a tube 41 which may be provided with a bank of louvers 43 which connect the interior of the tube with the cham-

ber 19. The tube 41 is preferably aligned with the tube 37.

In operation, gas enters the projecting end 28 of the inlet tube 27 and is discharged by the tube 27 into a first expansion chamber 23. The gas from this chamber enters the connector tube 37 and is discharged by it into the second expansion chamber 21. The gas in chamber 21 flows through the tube 41 into a third expansion chamber 17 and then out of the muffler through the outlet tube 31. The outlet tube may have a louver bank 45 enclosed by a shell 47 mounted on the tube 41 to form a spit chamber 49 for attenuating high frequencies and roughness. Medium to high frequencies are attenuated by virtue of the louver bank 43 opening into chamber 19. If desired, an additional middle frequency attenuating louver bank, as shown by the phantom lines 51, may be formed in that portion of inlet tube 27 within the chamber 19 and this will also provide for some cross bleeding from tube 27 to tube 41 to minimize backpressure.

The muffler 101 of FIG. 2 has a tubular and preferably oval outer shell 103 which is closed at opposite ends by an inlet header 105 and an outlet header 107 which are interconnected with the ends of the shell by gas-tight joints 109. Transverse partitions 111, 113, 115, and 117 extend across the full width of the shell 103 and are longitudinally separated from each other to form interior chambers 119, 121, 123, 125, and 127. The header 105 and the partition 111 have aligned necks 129 which provide openings that receive an inlet tube 131 which has a bushing portion 133 projecting outside of the muffler and an outlet portion 135 projecting a substantial distance into the chamber 121. The outlet header 107 and the partitions 115 and 117 have aligned necks 137 which provide openings that telescopically receive an outlet tube 139, which conducts gas from the chamber 123 to the outlet bushing portion 141 that may be secured to a tailpipe in an exhaust system. The outlet tube 139 may have a series of openings 143 connecting it to the chamber 125 and it may also have a louver bank opening into a shell mounted on the tube 139 to provide a spit chamber construction 145 (shown in phantom lines) similar to that indicated at 49, in FIG. 1, this construction being located in the chamber 127.

The partitions 113, 115, and 117 have aligned necks 147, which provide openings to receive a connector tube 149 which has a predetermined imperforate length and which is open at opposite ends to connect the chamber 121 to the chamber 127, it being noted that one end of the tube 149 overlaps the projecting portion 135 of the tube 131. The partitions 115 and 117 also have aligned necks 151 which provide openings that receive and support a tube 153 which connects the chamber 127 to the chamber 123. The tube 153 is preferably provided with a louver bank 155 to acoustically connect gas flowing through it with the chamber 125 and with the outlet tube 139 by way of openings 143.

In operation of the muffler 101, gas from an exhaust pipe connected to the projecting portion 133 of the inlet tube 131 is discharged into a midportion of a first expansion chamber 121, it being connected also by means of a louver bank 157 to the otherwise closed resonator chamber 119 for removing sound in a medium frequency range. The gas leaving tube 131 reverses direction to enter the imperforate tube 149 from which

it is discharged into a second expansion chamber 127. The gas in chamber 127 then flows through tube 153 to a third expansion and cross-over chamber 123 with medium frequencies being attenuated by the louver bank 155 opening into chamber 125. Gas from chamber 123 then enters the outlet tube 139 to flow through the outlet bushing portion 141 to the tailpipe of an exhaust system, with medium frequencies being silenced by the connection through holes 143 with chamber 125 and, if desired, high frequencies and roughness being silenced by the spit chamber 145.

In FIG. 3, the muffler 201 is a tubular outer shell 203 that is preferably oval in cross section and which is closed at opposite ends by an inlet header 205 and an outlet header 207 which are connected to the ends of the shell by gas-tight joints 209. A pair of transverse internal partitions 211 and 213 are supported inside the shell 203 and extend across its full width. The partitions divide the shell 203 into three internal chambers 215, 217, and 219. The partitions 211 and 213 have aligned necks 221 which provide openings to receive and support an inlet tube 223 that has an inlet bushing portion 225 projecting outside of the muffler for attachment to an exhaust pipe. That portion of the tube 223 within the chamber 217 has a bank of louvers 225 which open into the chamber 217. The outlet header 207 and the partitions 211 and 213 have aligned necks 227 which provide openings to receive and support an outlet 229 that has an outlet bushing portion 231 projecting outside of the muffler for connection to a tailpipe in an exhaust system. The tube 229 also has a louver bank 233 opening into the chamber 217 to provide for cross bleeding with the louver bank 225 and like the louver bank 225 to attenuate sound in a medium frequency range. The partitions 211 and 213 also have aligned necks 235 that receive and support a connecting tube 237 of predetermined imperforate length that is open at opposite ends to connect a first expansion chamber 219 with a second expansion chamber 215.

In operation of the muffler 201, gas entering the inlet tube 223 is discharged into the first expansion chamber 219 with some cross bleeding and medium frequency silencing being provided by the louver bank 225 and the louver bank 233. The gas in chamber 219 enters the tube 237 and is discharged by it into the second expansion chamber 215 and leaves this chamber by way of the outlet tube 229.

The muffler 301 of FIG. 4 is of a double tri-flow type and has an oval tubular outer shell 303 which is closed at its inlet end by an inlet header 305 and at its outlet end by an outlet header 307, being connected to the headers in gas-tight joints 309. The interior of the shell 303 is subdivided into chambers 311, 315, 317, 319, and 321 by a series of transverse partitions 323, 325, 327, and 329 which extend across the full width of the shell 303 and are suitably attached to it in a known manner.

The inlet header 305 and the partition 323 have aligned necks 331 which receive and support an inlet tube 333 that has an inlet bushing portion 335 extending outside of the muffler for connection to an exhaust pipe. The outlet header 307 and the partitions 327 and 329 have aligned necks 337 that receive and support an outlet tube 339 which has a bank of louvers 341 opening into chamber 319 and an outlet bushing portion 343 projecting outside of the muffler for attachment to a tailpipe. The partitions 327 and 329 also have aligned

necks 345 which receive and support a tube 347 that connects chamber 321 and 317 and which has a bank of louvers 349 opening into the chamber 319 and providing for cross bleeding with the louver bank 341. The four partitions 323, 325, 327, and 329 have aligned necks 351 that provide openings to receive and support a connecting tube 353 having predetermined imperforate length that connects the first expansion chamber 311 with the second expansion chamber 321. The partition 323 also has a neck 355 that provides a short tubular section connecting the chamber 315 with the chamber 311.

In operation of the muffler 301, gas entering the muffler through the inlet tube 333 is discharged into an expansion and crossover chamber 315. It flows through the neck 355 into the expansion chamber 311 where it enters the end of the tube 353 from which it is discharged at the other end of the muffler into the expansion chamber 321. Gas in chamber 321 flows through the tube 347 into the expansion and cross-over chamber 317 from which it flows into the outlet tube 339 and out through the bushing portion 343 to the tailpipe.

In accordance with the invention the mufflers 1, 101, 201, and 301 have a common feature in their intermediate tubes 37, 149, 237, and 353, respectively, in combination with pairs of expansion chambers 23 and 21, 121 and 127, 219 and 215, and 311 and 321, respectively. In each of the mufflers except muffler 1 the expansion chambers are separated by one or more intermediate chambers. Thus, in muffler 101 two chambers (123 and 125) separate the first and second expansion chambers 121 and 127; in muffler 201 one chamber (217) separates the first and second expansion chambers 219 and 215; and in muffler 301 three chambers (315, 317, and 319) separate the first and second expansion chambers 311 and 321. In each instance the expansion chamber has only two gas ports (i.e., an inlet and an outlet) and the intermediate tube provides one of the ports. In each instance the intermediate tube is open at opposite ends and imperforate throughout its length so that there is a measured, predetermined effective (i.e. non-perforated) length for tuning purposes. It is preferred that the first and second expansion chambers be of the same length and area as is the case with mufflers 201 and 301. In cases where they are of different lengths, as in mufflers 1 and 101, the average length may be used in tuning calculations based on the empirical lower cutoff frequency equation published in NACA TN 1192 (equation A18). In this equation, the imperforate length of the intermediate tube should be used in the event a partially perforated tube is used, solution of the equation yielding the approximate low cutoff frequency for a double expansion chamber with connecting tube.

The imperforate connecting or intermediate tubes 37, 149, 237, and 353 and their pairs of expansion chambers may be tuned to attenuate a broad band of frequencies extending upwardly from the aforementioned low cutoff frequency. The low cutoff frequency may be adjusted by adjusting the relative areas of the tube and chambers, the length of the tube, and the average length of the chambers. The combination of tube and expansion chambers at an intermediate part of the gas flow paths in the mufflers illustrated is especially useful in attenuating sound in a broad band extending from low to lower medium frequencies, the upper cutoff frequency not being readily determined except by

actual test. Frequencies in a band that is higher than that attenuated by the broad band attenuation of intermediate tube and expansion chambers (though there may be some overlap at the high end of said broad band) are attenuated in the inlet and outlet tube portions and in tubes 153 and 347 of the gas flow paths by the louver banks, spit chambers, and tuning chamber 119 which may be tuned to remove a desired frequency. As a consequence, the structures illustrated provide relatively simple but very efficient mufflers for attenuating sound throughout a wide frequency range from low to high.

Modifications in the structures shown may be made without departing from the spirit and scope of the invention.

I claim:

1. A muffler comprising an elongated housing having an inlet and an outlet, an inlet gas flow tube in said housing connected to said inlet and an outlet gas flow tube in said housing connected to said outlet, at least two transverse partitions in said housing subdividing it into at least three transverse chambers, one of said chambers comprising a first expansion chamber and another of said chambers comprising a second expansion chamber, first means connecting said inlet tube with said first expansion chamber so that gas from the inlet tube flows into the first expansion chamber, second means connecting said outlet tube with said second expansion chamber so that gas in the second expansion chamber flows into the outlet tube, and a substantially imperforate intermediate tube supported by said partitions having a predetermined length and having an inlet end opening into the first expansion chamber and an outlet end opening into the second expansion chamber to provide a path for gas flow from the first to the second expansion chamber, said first means and the inlet end of said intermediate tube forming the only ports for the first expansion chamber and the second means and the outlet end of the intermediate tube forming the only substantial flow ports for the second expansion chamber, the length of said intermediate tube along with the length of the expansion chambers and the ratio of the areas of the chambers and intermediate tube being selected to tune said chambers and tube to attenuate a broad band of sound frequencies having a substantially predetermined cutoff frequency at the low end of the band, said first and second expansion chambers being longitudinally adjacent to each other and said intermediate tube being supported by the partition separating said expansion chambers, the third of said transverse chambers forming a part of one of said means.

2. A muffler as set forth in claim 1 wherein at least one of said inlet and outlet tubes has a perforated wall to provide means for attenuation of frequencies higher than said broad band.

3. A muffler as set forth in claim 2 including a third transverse partition acting with said two partitions to subdivide the housing into four transverse chambers, the fourth of said chambers being located between the third chamber and one of the expansion chambers and including gas flow means connecting said one expansion chamber with said third chamber, said gas flow means along with said third chamber forming a part of said one of said first and second means.

4. A muffler as set forth in claim 3 wherein said gas flow means comprises a tube having a perforated wall

opening into said fourth chamber to provide means for attenuation of frequencies higher than said broad band.

5. A muffler comprising an elongated housing having an inlet and an outlet, an inlet gas flow tube in said housing connected to said inlet and an outlet gas flow tube in said housing connected to said outlet, at least two transverse partitions in said housing subdividing it into at least three transverse chambers, one of said chambers comprising a first expansion chamber and another of said chambers comprising a second expansion chamber, first means connecting said inlet tube with said first expansion chamber so that gas from the inlet tube flows into the first expansion chamber, second means connecting said outlet tube with said second expansion chamber so that gas in the second expansion chamber flows into the outlet tube, and a substantially imperforate intermediate tube supported by said partitions having a predetermined length and having an inlet end opening into the first expansion chamber and an outlet end opening into the second expansion chamber to provide a path for gas flow from the first to the second expansion chamber, said first means and the inlet end of said intermediate tube forming the only ports for the first expansion chamber and the second means and the outlet end of the intermediate tube forming the only substantial flow ports for the second expansion chamber, the length of said intermediate tube along with the length of the expansion chambers and the ratio of the areas of the chambers and intermediate tube being selected to tune said chambers and tube to attenuate a broad band of sound frequencies having a substantially predetermined cutoff frequency at the low end of the band, said third transverse chamber being located between said first and second transverse chambers and forming a part of one of said first and second means.

6. A muffler as set forth in claim 5 wherein said outlet tube has an inlet opening into said third transverse chamber whereby said third transverse chamber forms a part of said second means.

7. A muffler as set forth in claim 6 including a third transverse partition acting with said two transverse partitions to form a fourth transverse chamber in said housing, said fourth transverse chamber being located between said second expansion chamber and said third transverse chamber and including gas flow means connecting said second expansion chamber and said third transverse chamber, said gas flow means forming a part of said second means.

8. A muffler as set forth in claim 7 wherein said gas flow means comprises a tube having a perforated wall opening into said fourth chamber to provide means for attenuation of frequencies higher than said broad band.

9. A muffler as set forth in claim 8 wherein said outlet tube has a perforated wall opening into said fourth chamber to provide for by-pass flow of gas and to provide means to attenuate sound frequencies higher than said broad band.

10. A muffler as set forth in claim 9 wherein the outlet end of said inlet tube opens into the first expansion chamber to form said first means.

11. A muffler as set forth in claim 10 including a fourth transverse partition forming a fifth transverse chamber, said inlet tube extending through said fifth chamber and having a wall therein with aperture means opening into the chamber and forming the only connection of said chamber with gas flowing through the

muffler whereby said fifth chamber and aperture means form a resonator chamber tuned to attenuate a predetermined frequency.

12. A muffler as set forth in claim 9 including a fourth transverse partition forming a fifth transverse chamber located between said first and second expansion chambers, said inlet tube having an outlet opening into said fifth chamber and said fifth chamber having gas flow means connecting it with the first expansion chamber and forming a part of said first means.

13. A muffler comprising an elongated housing having an inlet and an outlet, an inlet gas flow tube in said housing connected to said inlet and an outlet gas flow tube in said housing connected to said outlet, at least two transverse partitions in said housing subdividing it into at least three transverse chambers, one of said chambers comprising a first expansion chamber and another of said chambers comprising a second expansion chamber, first means connecting said inlet tube with said first expansion chamber so that gas from the inlet tube flows into the first expansion chamber, second means connecting said outlet tube with said second expansion chamber so that gas in the second expansion chamber flows into the outlet tube, and a substantially

imperforate intermediate tube supported by said partitions having a predetermined length and having an inlet end opening into the first expansion chamber and an outlet end opening into the second expansion chamber to provide a path for gas flow from the first to the second expansion chamber, the length of said intermediate tube along with the length of the expansion chambers and the ratio of the areas of the chambers and intermediate tube being selected to tune said chambers and tube to attenuate a broad band of sound frequencies having a substantially predetermined cutoff frequency at the low end of the band, said third transverse chamber being located between said first and second expansion chambers and said intermediate tube being substantially longer than said third chamber and extending through said third chamber and overlapping the inlet and outlet gas flow tubes in said first and second chambers, said inlet and outlet tubes each extending through said third chamber and having aperture means in the walls thereof opening into said third chamber to provide for by-pass flow of gas and to provide said means to attenuate sound frequencies higher than said broad band.

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