June 25, 1940. A. S. CHIPLEY 2,205,899

SILENCING DEVICE FOR PULSATING GASES

Filed May 1, 1939

Fig. 1.

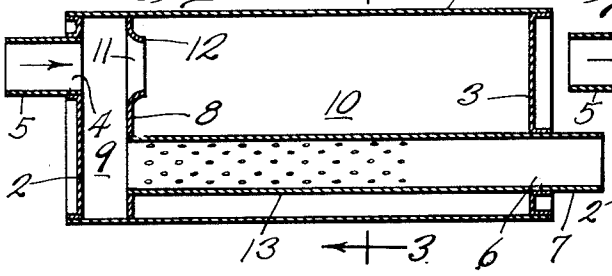


Fig. 2.

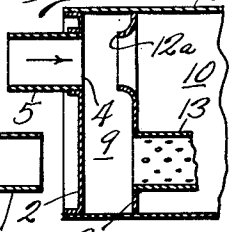


Fig. 3.

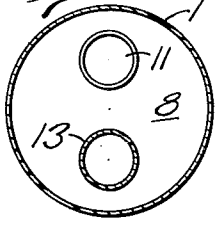


Fig. 4.

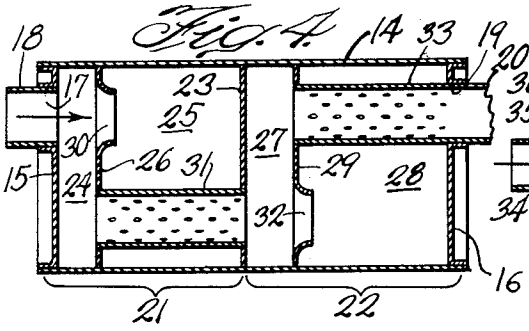
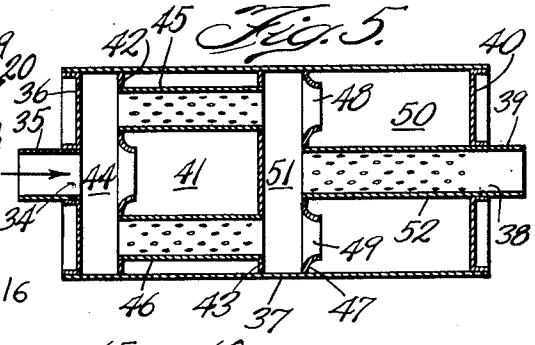


Fig. 5.



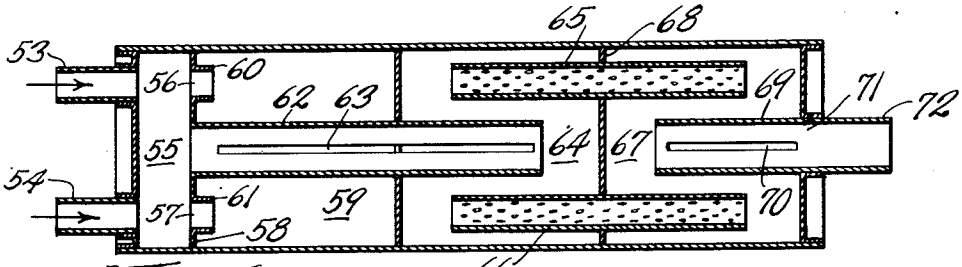


Fig. 6.

Fig. 7.

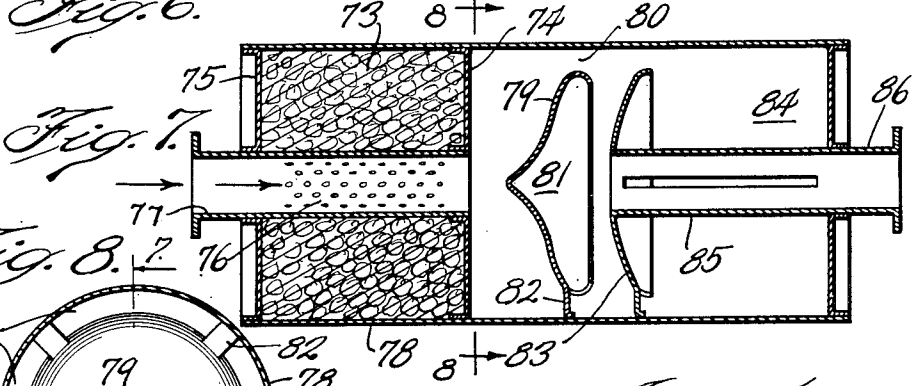
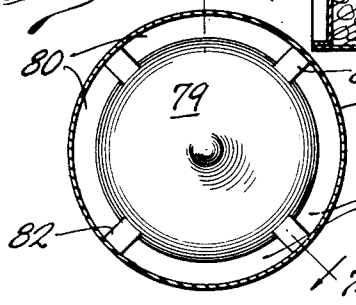


Fig. 8.



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SILENCING DEVICE FOR PULSATING GASES

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Application May 1, 1939, Serial No. 271,031

14 Claims. (Cl. 181—57)

This invention relates to devices used for the prevention of noise caused by flowing, pulsating gases, such as the exhaust gases of internal combustion engines, or, as the terms are loosely used, to mufflers and silencers for such pulsating gas systems.

Although the invention is useful for the prevention of noise caused by pulsating gases generally, including, for example, the intake and delivery of air compressors, the most severe conditions are met in the prevention of noise caused by the exhaust of internal combustion engines and for this reason the invention will be illustrated and described as applied to this particular problem.

A considerable variety of silencer constructions have been used and are now in use in coping with the problem of preventing or reducing to a minimum the noise attendant upon the operation of internal combustion engines. These various forms of apparatus operate on divers principles and are grounded on as many different conceptions of the causes of noise. A particular silencer may, for example, be of the baffle, resonator, three-pass, two-pass, expansion chamber or "pack" type, in simple or compound form, or it may embody a combination of two or more of these well-known types of apparatus. The object of combining the different forms of apparatus is to take advantage of the characteristics peculiar to each and thus obtain a device having the desired muffling characteristics. The resultant product of such a combination contains a plurality of classifiable "muffling sections." This expression will be used herein to denote a unit of one of the well-known forms of muffling apparatus, such as those enumerated above.

A new type of noise-preventing device, known as the "snubber," has recently been developed and commercially used. This device comprises a snubber tube into which the exhaust gases are projected at high velocity from the exhaust ports of the engine, an unconstricted shunt or by-pass passageway being provided around the snubber tube from the inlet to the outlet of the device. The snubber may be used as the silencer itself or a snubber section may be employed in combination with other types of muffling sections in the building up of a composite device designed to accomplish a specified function with the desired degree of perfection. The snubber operates on a gas-inertia principle and, although it differs in operation from most of the other types of mufflers and silencers in that it operates to modify the gas "slug" pressure-velocity peaks and thus remove the primary cause of noise rather than to merely suppress the noise after it has been generated or minimize secondary reverberation in the exhaust system, it may be loosely referred to as a muffler or silencer.

The snubber tube of a snubber type of silencer is generally in the form of a perforated sheet metal member. It has been found that under certain circumstances, for example, when the device is used with a Diesel engine, especially one of the low speed, low pressure type, solid materials carried by the exhaust gases stick to the inside surface of the snubber tube and cause an accumulation of tarry deposits. This material may in time plug the perforations and deprive the silencer of its ability to effectively snub the exhaust slugs. Accordingly, one object of the present invention is to obviate the possibility of plugging of the snubber tube of a snubber type of silencer, or a snubber section thereof. A further object is to simplify this type of apparatus and to thereby reduce the cost of the device without at the same time sacrificing its high silencing efficiency or depriving it of other desirable characteristics.

In the accompanying drawing:

Fig. 1 is a longitudinal, sectional view of a simple embodiment of the invention;

Fig. 2 is a fragmentary view, similar to that of Fig. 1, illustrating a permissible modification;

Fig. 3 is a transverse, sectional view taken at the line 3—3 of Fig. 1;

Figs. 4 and 5 are longitudinal, sectional views of compounded forms of the invention;

Fig. 6 is a longitudinal, sectional view illustrating certain modifications of the invention and the combination of the invention with another type of muffling section;

Fig. 7 is a longitudinal, sectional view (taken at the line 7—7 of Fig. 8) of another combination device including a modified form of snubber section; and

Fig. 8 is a transverse, sectional view taken at the line 8—8 of Fig. 7.

Referring specifically to Fig. 1 which illustrates a simple embodiment of the invention, the unit is enclosed within a shell including a side wall 1 of circular or elliptical cross section and end headers 2 and 3. End header 2, which may be referred to as the inlet-end header, is provided with an inlet opening 4 through which the gases enter the shell as indicated by the arrow. An inlet snout 5 may be attached to the inlet-end header at the inlet opening for convenience in mounting the device in the exhaust system of

the engine. An outlet opening 6 is provided in outlet-end header 3 and an outlet snout 7, illustrated as integral with conduit 13, may be mounted in header 3. A partition 8 is arranged within the shell in spaced relation to inlet-end header 2 and divides the volume of the device into a by-pass chamber 9 and a snubber chamber 10. An opening 11 is provided in partition 8 in alignment with inlet opening 4 and snout 5. This opening is preferably about as large as the area of inlet opening 4. It is preferable, although not essential, to develop the sheet metal of partition 8 at the periphery of opening 11 to form a lip 12 for the purposes hereinafter more fully stated. This lip may be developed away from inlet opening 4, as illustrated at 12 in Fig. 1, or it may be carried toward the inlet opening as illustrated at 12*a* in Fig. 2. A conduit 13 connecting by-pass chamber 9 with the outlet of the device completes the structure of the unit of Fig. 1. The walls of conduit 13 are apertured in any suitable manner, as by perforating or slotting, to provide communication between snubber chamber 10 and the interior of the conduit. In the simple form of the device, as that shown in Fig. 1, it is desirable to limit direct communication between the conduit and snubber chamber 10 to the portion of the conduit remote from the outlet end of the device by perforating only that portion, as shown.

In the operation of the device, the exhaust gas slugs which are emitted from the exhaust ports of the engine at high velocity and under high pressure are conducted into the shell and toward opening 11 via the exhaust pipe (not shown) and inlet snout 5. The portion of each slug having sufficient inertia to do so, enters snubber chamber 10 through opening 11 while the remainder of the gases of the slug, the tailings traveling at lower velocities, follow the path of least resistance and by-pass directly to conduit 13 and thence to the atmosphere via outlet opening 6, outlet snout 7 and the tail pipe of the exhaust system. It will be seen that the path followed by the tailings is through an unconstricted passageway, that is, one whose transverse area at any point is not less than the area of the inlet snout 5 and opening 4. This feature assures low back pressure operation of the silencer. The rapidly traveling gases entering chamber 10 through opening 11 are snubbed by reason of the limited means of escape from this chamber provided by the openings in the walls of conduit 13. The gases in chamber 10 cushion the impact of the entering gases, being compressed and absorbing the kinetic energy thereof. The gases then expand in chamber 10 and the pressure dissipates as the gases pass from the chamber into conduit 13 through the openings in the walls of the conduit. These gases follow the tailings to the atmosphere.

Although a device provided with a simple sharp-edged opening 11 without the lip 12 will operate to substantially modify the pressure-velocity peaks of the exhaust gases, and thus prevent the noise-causing impact of the slugs with the atmosphere, it has been found that some edge noise is generated by the high-velocity movement of gases past the sharp edge of partition 8 as they pass through the opening. This undesirable noise is eliminated by means of a lip or flange, such as is shown at 12 or 12*a*, this lip operating to ease the gases into chamber 10 without necessitating their passage at right angles to the sharp edge of the partition. The lip may be belled to a curved profile, as shown in Figs. 1 and 2, or may be square, as shown in Fig. 6. A lip developed in either direction from the partition is effective although the downstream development is preferred.

The silencer illustrated in Fig. 4 is composed of two muffling sections compounded to cooperate in smoothing the flow of gases passing through the unit. Each of these sections is substantially the same as the device described above. The operating apparatus is housed in a shell composed of side walls 14 and end headers 15 and 16 having inlet opening 17 and snout 18 and outlet opening 19 and snout 20, respectively. Outlet snout 20 is illustrated as integral with conduit 33 although it may, of course, be separate. The volume of the shell is divided into primary section 21 and secondary section 22 by intermediate partition 23. Primary muffling section 21 is divided into primary by-pass chamber 24 and primary snubber chamber 25 by partition 26 and secondary muffling section 22 is divided into secondary by-pass chamber 27 and secondary snubber chamber 28 by partition 29. Partition 26 is provided with an opening 30 in alignment with inlet opening 17 and an apertured conduit 31 passes through chamber 25 and connects the by-pass chambers 24 and 27. An opening 32 is provided in partition 29 in alignment with conduit 31 and an apertured conduit 33 passes through secondary snubber chamber 28 and connects secondary by-pass chamber 27 with outlet opening 19.

The operation of the individual sections of this silencer is the same as that described in connection with the device of Fig. 1. The exhaust slugs are operated upon successively and the pressure-velocity peaks modified by the action of each. In addition to the individual operation of the two sections, it appears that an interference phenomenon between them contributes to the effectiveness of the compounded unit in preventing noise. This may be due to the irregularity of the impacts of the successive slugs as they project into the successive chambers and as the modified slugs strike the atmosphere, or it may be due, at least in part, to interference of the sound waves within the device.

A modified form of the silencer of Fig. 4 is shown in Fig. 5. In this device the inlet opening 34 and snout 35 are placed at the center of inlet-end header 36 of shell 37 and outlet opening 38 and snout 39 are placed in the center of outlet-end header 40. Primary snubber chamber 41 formed by partitions 42 and 43 receives the nuclear portion of each gas slug entering the device at inlet opening 34, the tailings of each slug shunting through primary by-pass chamber 44 to the several apertured conduits passing through chamber 41, such as conduits 45 and 46, two or more of which may be provided. The tailings are thus divided into a plurality of streams which pass on to the second section of the silencer. The expanded gases from chamber 41 also pass into the next section of the silencer at a plurality of points. An opening is provided in partition 47 in alignment with each of the conduits 45, 46 as shown at 48 and 49. Gases entering the second section of the silencer may project into secondary snubber chamber 50 or pass through secondary by-pass chamber 51 directly into apertured conduit 52. In either case the gases then proceed to the atmosphere via outlet opening 38.

The silencer of Fig. 6 embodies modifications of certain of the elements of the apparatus above described and illustrates the combination of a

snubbing section with a compound section composed of two treatment chambers each of which is known to the art as a "two-pass" section, that is, a chamber having non-aligned inlet and outlet apertured tubes extending into the chamber from opposite points. This combined unit, as illustrated, is provided with two inlets 53 and 54 for connection, for example, to the two banks of cylinders of an engine of the "twin" type. These inlets open into by-pass chamber 55. Openings 56 and 57 in partition 58 are in alignment with openings 53 and 54, respectively, and permit the passage of the incoming gases into snubber chamber 59. The lips or flanges 60 and 61 at openings 56 and 57 are substantially equivalent to the curved lips described in connection with the embodiments of Figs. 1 to 5, differing only in that they meet partition 58 at right angles rather than with a curve. A conduit 62 having a slot 63 connects by-pass chamber 55 with the expansion chamber 64 of the next succeeding muffling section. The slot 63 is substantially equivalent to perforations and permits gases to pass from chamber 59 into the conduit. Perforated tubes 65 and 66 conduct the gases from chamber 64 into chamber 67 which latter forms the third muffling section of the combination unit, being separated from the second muffling section by partition 68. An outlet conduit 69 which is provided with a slot 70 carries the gases from chamber 67 through outlet opening 71 and outlet snout 72 to the atmosphere.

In the operation of the silencer of Fig. 6, the sharp pressure-velocity peaks of the gas slugs are modified by the snubbing action of the first muffling section of the silencer and the pulsations are further smoothed as the gases pass through the second and third sections of the unit in succession. The gases are then exhausted to the atmosphere in a relatively steadily flowing stream.

The combination unit of Fig. 7 is specially designed to remove high-frequency noises and to reduce so-called "shell" noise to a minimum. It also illustrates a snubber section which is essentially the same as those above described but in slightly different form. In this embodiment the snubbing section follows a "pack" section comprising sound-absorbing material 73, such as steel wool, glass silk, exfoliated vermiculite, etc., filled into the space between partition 74, inlet-end flange 75, perforated tube 76 forming substantially an extension of inlet snout 77 and shell 78 of the silencer. The gases, after passing through the pack section, enter the snubber section. The gas stream entering the snubber section from tube 76 is spread by baffle 79 and directed radially from the axis of the silencer. The gases then pass through openings 80 which provide an annular entrance into the by-pass zone 81 of this section of the silencer. Baffle 79 is mounted to the shell 78 of the unit, as shown at points 82. A partition 83 having peripheral openings in alignment with openings 80 in baffle 79 separates snubber chamber 84 from by-pass zone 81. Slotted conduit 85 connects the by-pass zone with outlet fitting 86.

It will be apparent that the snubber section of the device of Figs. 7 and 8 operates as above described in connection with the previously described forms of snubbing section. The high-velocity portions of each gaseous slug projects into chamber 84 through the openings in partition 83 which are in alignment with openings 80 in baffle 79. The tailings may by-pass through zone 81 directly to conduit 85 and thence to the atmosphere. Gases entering chamber 84 pass into conduit 85 through the slot therein and then also pass to the atmosphere.

Silencers of the snubber type, such as the device of this invention, have the important advantage over units of the resonator type that they may be placed at any point in the exhaust line with substantially the same effectiveness. Since the primary cause of noise is obviated by means of the snubbing unit, the troublesome period noises do not occur. Also, back pressures are negligible since an unconstricted passageway is provided through each snubber or snubber section. The improved snubber construction described herein is exceedingly simple in construction and therefore inexpensive to manufacture. The various forms of the individual elements of the silencers described herein may be used in any of the arrangements disclosed and in other equivalent units of the type exemplified herein.

I claim:

1. In a device of the character described including a shell having an inlet opening and an outlet opening, conduit means adapted to conduct gases into said shell at said inlet opening, means forming a snubber chamber within said shell, said means including a partition arranged in spaced relation to said shell at said inlet opening to form a by-pass chamber and having an opening therein in alignment with said conduit means, and at least one conduit passing through said snubber chamber establishing communication between said by-pass chamber and said outlet opening, said conduit having an apertured wall and opening into said by-pass chamber at a point in non-alignment with said conduit means, the construction and arrangement of said device being such that gases entering said snubber chamber are free to expand substantially unimpeded therein and thereafter pass therefrom through the aperture or apertures in said conduit.

2. A device in accordance with claim 1 in which the apertured wall of the conduit passing through the chamber comprises a wall having distributed perforations therein.

3. A device in accordance with claim 1 in which the apertured wall of the conduit passing through the chamber comprises a wall having an elongated slot therein.

4. A device in accordance with claim 1 in which the opening in said partition is provided with a lip at its periphery.

5. In a device of the character described including a shell having an inlet opening and an outlet opening, conduit means adapted to conduct gases into said shell at said inlet opening, means forming a snubber chamber within said shell, said means including a partition arranged in spaced relation to said shell at said inlet opening to form a by-pass chamber and having an opening therein in alignment with said conduit means, and a conduit passing through said snubber chamber establishing communication between said by-pass chamber and said outlet opening, the portion of said conduit remote from said outlet opening being apertured, said conduit opening into said by-pass chamber at a point in non-alignment with said conduit means, the construction and arrangement of said device being such that gases entering said snubber chamber are free to expand substantially unimpeded therein and thereafter pass therefrom through the aperture or apertures in said conduit.

6. In a device of the character described including a shell having a plurality of inlet openings and an outlet opening, conduit means adapted

to conduct the gases into said shell at each of said inlet openings, means forming a snubber chamber within said shell, said means including a partition arranged in spaced relation to said shell at said inlet openings to form a by-pass chamber and having an opening therein in alignment with said conduit means associated with each of said inlet openings, at least one conduit passing through said snubber chamber establishing communication between said by-pass chamber and said outlet opening, said conduit having an apertured wall and opening into said by-pass chamber at a point in non-alignment with said conduit means, the construction and arrangement of said device being such that gases entering said snubber chamber are free to expand substantially unimpeded therein and thereafter pass therefrom through the apertured wall of said conduit.

7. A device of the character described comprising a cylindrical shell, an inlet-end and an outlet-end header enclosing the space within said shell, said inlet-end header having an inlet opening and the outlet-end header having an outlet opening therein, an inlet snout associated with said inlet opening and adapted to conduct gases into said shell, a transverse partition within said shell spaced from said inlet-end header to form a by-pass chamber into which said inlet snout opens, said partition having an opening therein in alignment with said inlet snout, and an apertured tube passing through the space within said shell between said partition and said outlet-end header and connecting said by-pass chamber with said outlet opening, said conduit opening into said by-pass chamber at a point in non-alignment with said inlet snout.

8. A device in accordance with claim 7 in which said opening in said partition is provided with a lip at its periphery.

9. In a device of the character described including a shell having an inlet opening and an outlet opening, conduit means adapted to conduct gases into said shell at said inlet opening, means forming a primary snubber chamber within said shell, said means including a partition arranged in spaced relation to said shell at said inlet opening to form a primary by-pass chamber and having an opening therein in alignment with said conduit means, a tube passing through said primary snubber chamber and connecting with said by-pass chamber at a point in non-alignment with said conduit means, said tube having an apertured wall, means forming a secondary snubber chamber within said shell, said means including a partition spaced from a wall of said primary snubber chamber to form a secondary by-pass chamber and having an opening therein in alignment with said apertured tube, and a second tube passing through said secondary snubber chamber connecting said secondary by-pass chamber at a point in non-alignment with said apertured tube with said outlet opening, said second tube having an apertured wall.

10. A device in accordance with claim 9 in which the opening in said partitions are provided with lips at their peripheries.

11. A device of the character described comprising a cylindrical shell having end closure members, one of said end closures having an inlet opening located at the center thereof the other end closure having an outlet opening located at the center thereof, conduit means adapted to conduct gases into said shell at said inlet opening, a partition intermediate the ends of said shell dividing the volume thereof into a primary and a secondary section the former being adjacent said inlet opening and the latter being adjacent said outlet opening, a transverse partition within said primary section spaced from the end closure to form a primary by-pass chamber into which said inlet opening opens and having an opening therein in alignment with said conduit means, at least one apertured conduit within said primary section connecting said primary by-pass chamber at a point in non-alignment with said conduit means with said secondary section, a transverse partition within said secondary section spaced from said intermediate partition to form a secondary by-pass chamber into which said apertured conduit opens and having an opening therein in alignment with said apertured conduit, and a second apertured conduit within said secondary section connecting said secondary by-pass chamber at a point in non-alignment with said first-mentioned apertured conduit with said outlet opening.

12. A device in accordance with claim 11 in which said openings in said partitions within said sections are provided with lips at their peripheries.

13. In a device of the character described including an elongated shell having an inlet opening at one end and an outlet opening at the other end thereof, conduit means adapted to conduct gases into said shell at said inlet opening, a plurality of connected muffling sections arranged in series within said shell, the first muffling section being connected with said inlet opening and the last muffling section in the series being connected with said outlet opening, one of said sections comprising means forming a chamber, said means including a wall having an opening therein, means for conducting gases toward said opening in said chamber wall, and an apertured conduit passing through said chamber connecting the spaces on either side thereof, the upstream end of said apertured conduit opening at a point in said wall other than at said above-mentioned opening therein, the arrangement being such that said gases are free to flow into said chamber and thence into said conduit through the apertures therein or directly into said conduit at one end thereof.

14. In a device of the character described including a shell and means for conducting gases thereinto and means for conducting gases therefrom, a snubbing section arranged within said shell, said snubbing section consisting of: a wall forming a by-pass chamber on one side and a snubber chamber on the other side thereof within said section, said wall having an opening therein, inlet means for conducting gases into said section, said inlet means opening directly into said by-pass chamber and being in alignment with said opening in said wall so as to conduct the gases toward said opening, and at least one conduit having apertured walls passing through said snubber chamber and opening into said by-pass chamber for direct communication with said inlet means at a point other than at said opening in said wall, the construction and arrangement being such that gases conducted into said section pass forwardly therethrough and from said section through said conduit without reversal.

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