Oct. 25, 1949. L. R. BESTER 2,485,555

BAFFLE TYPE MUFFLER WITH PLURAL EXPANSION CHAMBER

Filed Dec. 15, 1944 4 Sheets-Sheet 1

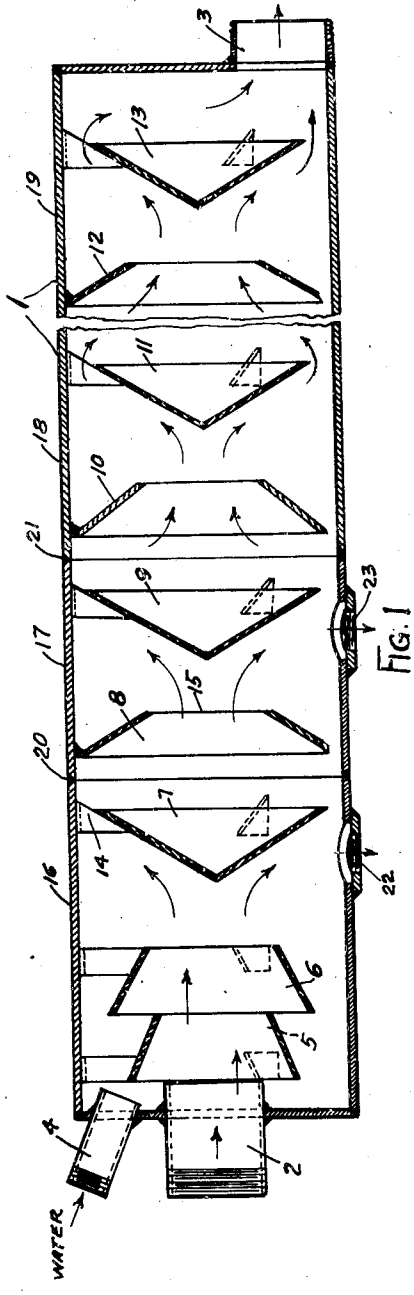

FIG. 1

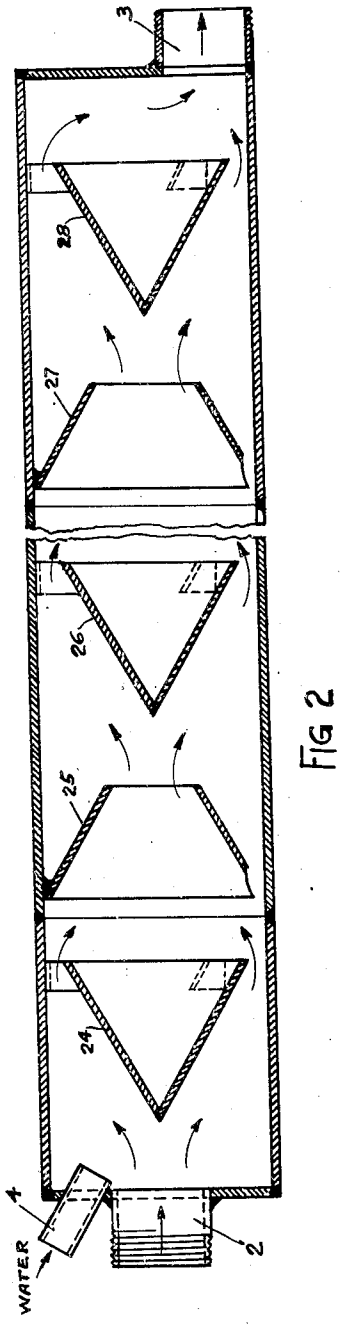

FIG 2

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BAFFLE TYPE MUFFLER WITH PLURAL EXPANSION CHAMBER

Filed Dec. 15, 1944 4 Sheets-Sheet 2

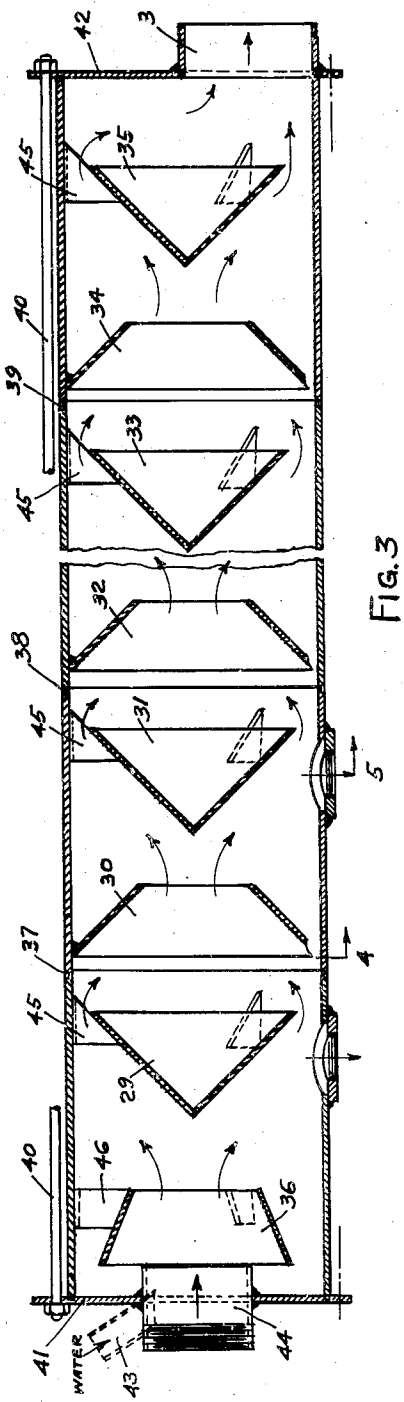

FIG. 3

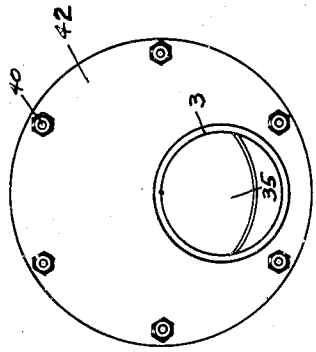

FIG. 6

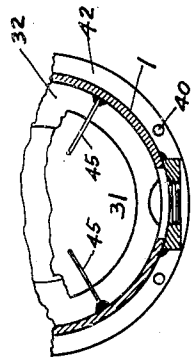

FIG. 5

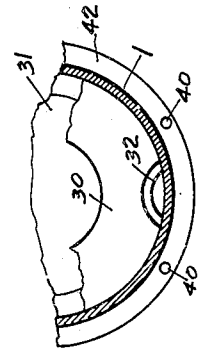

FIG. 4

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BAFFLE TYPE MUFFLER WITH PLURAL EXPANSION CHAMBER

Filed Dec. 15, 1944 4 Sheets-Sheet 3

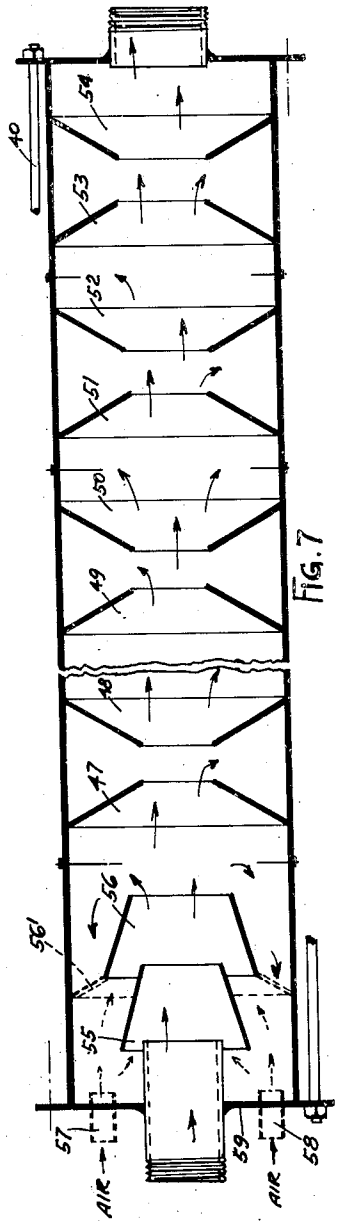

FIG. 7

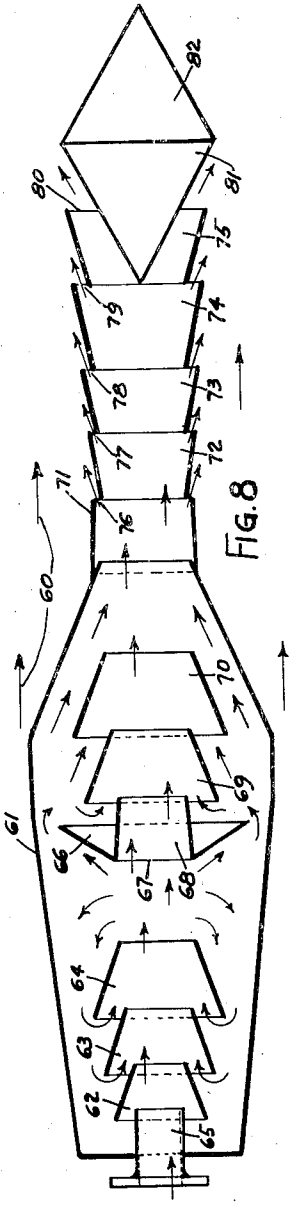

FIG. 8

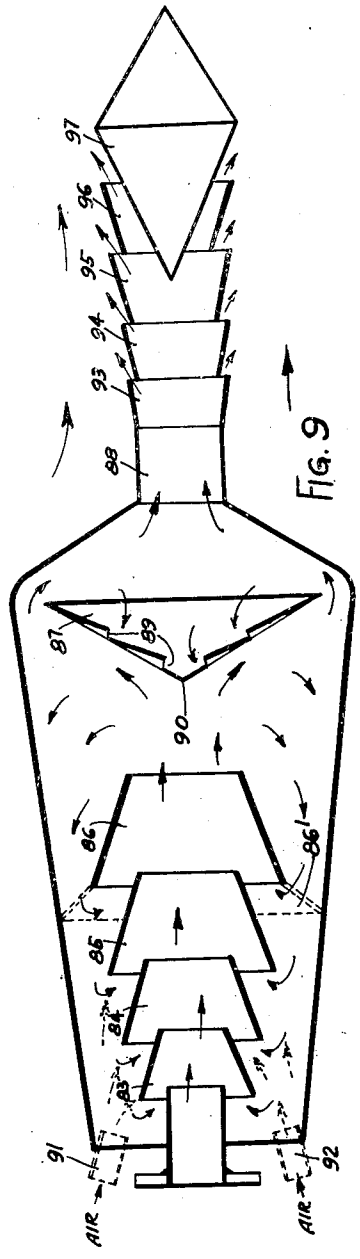

FIG. 9

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BAFFLE TYPE MUFFLER WITH PLURAL EXPANSION CHAMBER

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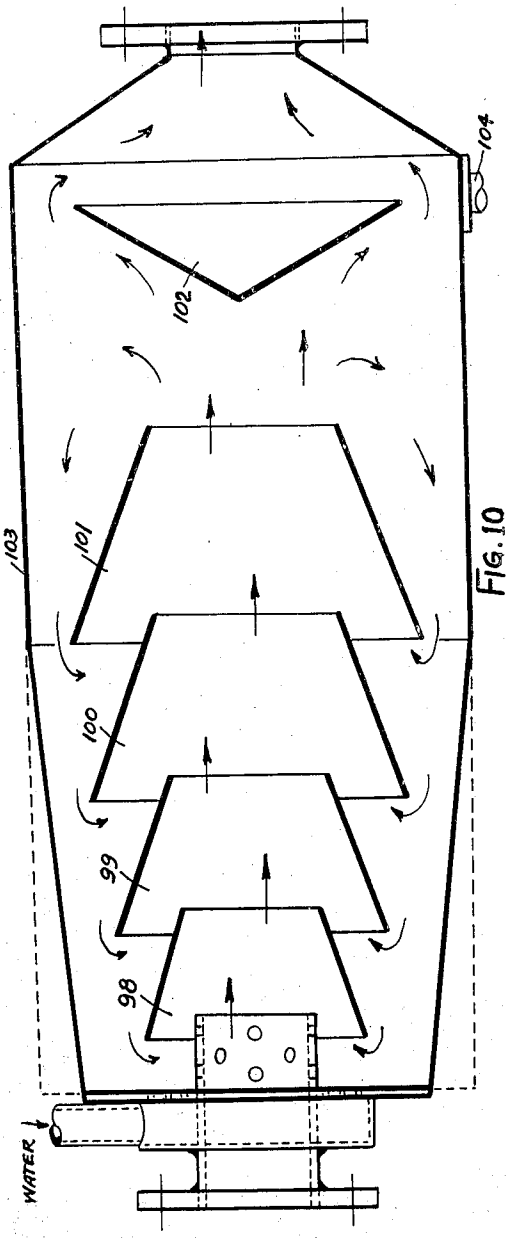

FIG. 10

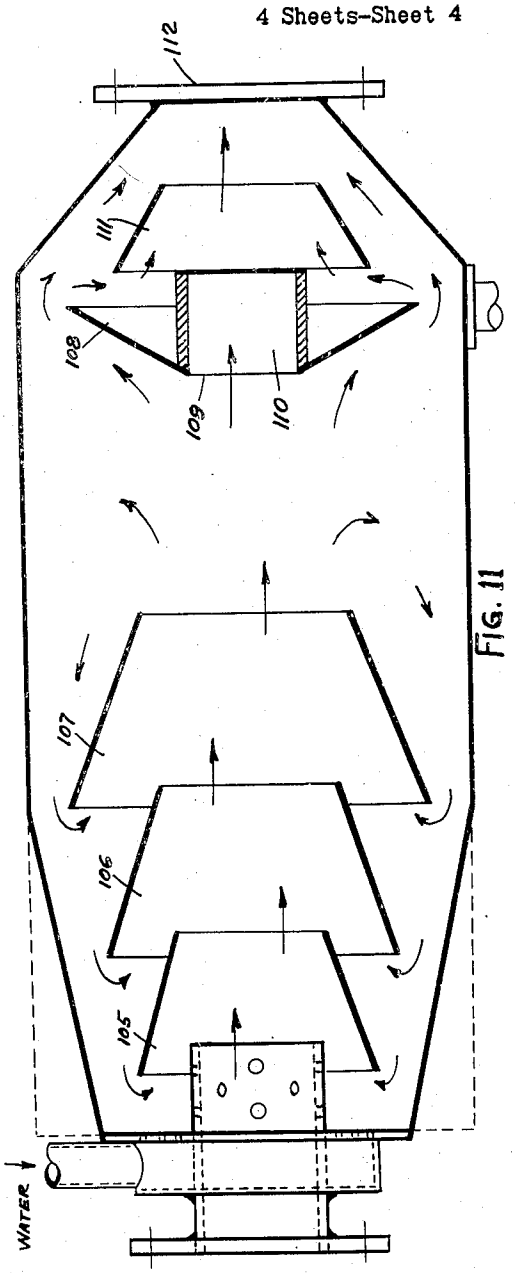

FIG. 11

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Patented Oct. 25, 1949 2,485,555

UNITED STATES PATENT OFFICE

2,485,555

BAFFLE TYPE MUFFLER WITH PLURAL EXPANSION CHAMBERS

Leonard R. Bester, New York, N. Y.

Application December 15, 1944, Serial No. 568,370

5 Claims. (Cl. 181—49)

(Granted under the act of March 3, 1883, as amended April 30, 1928; 370 O. G. 757)

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The present invention relates to mufflers, particularly those adapted for use with internal combustion engines. These mufflers may be of the wet or dry type. The several forms herein disclosed are based on the nozzle suction principle, and are designed so as to absorb the pulsations of the exhaust gases by successive expansions in chambers alongside the main gas passage, which is continuous throughout the muffler in one direction. The main passage for the gases, although interrupted by baffles, is never turned back in reverse direction but has a component toward the muffler outlet at all points along its course. The result is a great attenuation of the noise level without any appreciable rise in back pressure, as compared to mufflers now in common use.

One of the objects of this invention is to construct a muffler of the wet or dry type having a direct flow which, although diverted by a series of baffles, at no point reverses itself, but has at all points some component in the direction toward the muffler outlet.

Another object is to construct a muffler of the wet or dry type having a series of conical nozzles converging toward the outlet of the muffler and being annularly spaced from the wall of the muffler chamber.

Another object is the construction of a muffler of the wet or dry type having one or more conical shaped nozzles axially arranged therein near the inlet to the muffler and followed by a series of conical baffles, the alternate baffles of this series having openings around the periphery and through the center thereof, so as to cause the gases flowing therethrough to be alternately diverted outwardly around the periphery of one baffle and inwardly through the central opening in the next, the baffles with the peripheral openings having their apex turned upstream whereas the baffles having the central opening are turned so as to converge downstream.

Another object is to construct a muffler of the wet or dry type having a cylindrical casing with one or more conical shaped nozzles arranged near the inlet, and a series of conical baffles having central openings, the alternate baffles being turned to converge in opposite directions with respect to the flow of gases therethrough.

Another object is to construct a muffler of the wet or dry type having a casing of generally circular cross-section but having a smaller diameter at its inlet end, and a series of conical-shaped nozzles axially arranged therein, and a conical baffle at the enlarged end, annularly spaced from

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the casing and having its apex turned upstream, the outlet of the muffler being formed by a series of conical-shaped nozzles diverging outwardly to form annular outlets therebetween, the last conical nozzle being obstructed by a conical plug to form the last annular opening in the series. Further and more specific objects of this invention will become apparent as the description proceeds, having reference to the accompanying drawings, wherein:

Fig. 1 is a sectional view of one form of the muffler of this invention, illustrating a combination of nozzles and baffles in accordance with the principle used herein,

Fig. 2 is another form of muffler having a similar arrangement of alternate conical baffles, in which the conical walls make a smaller angle with the axis of the muffler,

Figs. 3 to 6 illustrate another construction wherein only one conical nozzle is used near the inlet end, and the series of alternately arranged conical baffles make an intermediate angle with the axis of the muffler,

Fig. 7 is a diagrammatical illustration of still another form of mufflers having a continuous passage straight through the middle of the muffler, the alternately arranged conical baffles all having central openings therein,

Fig. 8 represents diagrammatically a form of mufflers adaptable for use on aircraft engines where the exhaust is exposed to the air stream to obtain the benefit of the suction effect thereof,

Fig. 9 is a form similar to that of Fig. 8 but having a slightly different arrangement of the baffle and being provided with inlets for air near the inlet for the exhaust gases, and

Figs. 10 and 11 illustrate other forms of wet type mufflers.

The purpose of the conical nozzles used in the mufflers of the present invention is to recirculate and gradually expand the explosion impulses by successive expansions of the gases, and to inject them back into the direct flow, thereby causing attenuation of the excess pressure impulses by absorbing expansions and by reductions in temperature, so that the excess pressure pulsations in the expansion space after the last nozzle and before the outlet is reached, is almost nil. The gases simply flow through the outlet evenly without any explosion pulses and are smoothly pushed out by reason of the continuous accumulation of gases behind them. The use of the alternately arranged conical baffles further attenuates not only the pressure pulses but also the noise

so as to reduce it to a very low level by the time the gases reach the outlet. The inlet end of the muffler may be provided, as shown in some of the forms illustrated, with an arrangement to introduce cooling water where wet muffler types are desired, or to inject air in some of the forms for cooling purposes.

Referring more specifically to the several figures in the drawings, Fig. 1 shows a muffler having a cylindrical casing 1 with an inlet 2 at one end and an outlet 3 at the other. A water inlet 4 is also provided near the gas inlet 2. A pair of conical shaped nozzles 5 and 6 are suspended in series near the inlet and are annularly spaced from the cylindrical casing 1. These nozzles are followed by a series of conical baffles 7 to 13 for diverting the flow of gases, first outwardly through a peripheral opening 14 and then inwardly through a central opening 15, the openings having gradually increasing area all the way through the muffler from the inlet to the outlet end. In putting the muffler together, it may be first made in sections 16 to 19, each section 17, 18 and 19 having a pair of the baffles 8—9, 10—11, or 12—13, mounted therein, and the sections joined end to end at 20, 21, etc., by welding process. One or more drain outlets 22, 23 may be provided in the bottom of these sections for draining any excess of water accumulated therein.

Fig. 2 illustrates a similar arrangement of baffles, the conical walls 24 to 28 of which make a much smaller angle with the muffler axis. This muffler does not have any conical nozzles at the inlet end of the casing. In Figs. 3 to 6, a muffler having a similar arrangement of baffles 39 to 35 is shown but, only one conical nozzle 36 is used at the inlet end and the sections are put together at 37, 38, 39 etc., by matching shoulders, and are held together by through bolts 40 extending between the end plates 41 and 42. The water inlet 43 in this form is shown connected directly into the gas inlet 44. The baffles and nozzle are held in place by brackets 45, 46 mounted in the cylindrical casing sections.

Fig. 7 diagrammatically illustrates another form of mufflers having series of alternately arranged conical baffles 47 to 54, all of which have central openings for a direct axial flow of the gases through the entire muffler, and a pair of nozzles 55, 56 mounted near the inlet end of the casing, and the openings gradually increasing in size from the inlet to the outlet end.

Thus in this form, as well as in all other forms of mufflers shown herein, a series of expansion chambers is provided along the path of flow for the exhaust impulses to spread into, with annular return passages in the nozzle section for producing a suction effect by the flow of the impulses through the nozzles to draw back some of the expanded gases into the main flow. The expansion chambers are produced in various ways in the several forms of the invention. For example, in Fig. 1, the various baffles 7 through 13 are relatively flat and have sides which make an angle of not less than substantially forty-five degrees with the axis of the muffler to thereby produce considerable turbulence of the gases and some slowing down thereof. Each of the baffles is spaced from the adjacent baffles to produce chambers therebetween in which the pulses of gas can sequentially expand, be subjected to turbulence, and subsequently be scavenged therefrom. Thus, the baffle 7 deflects each pulse of gas to cause it to pass through the annular gap 14 between baffle 7 and casing 1 and enter the chamber between baffle 7 and baffle 8 where the gas expands with considerable turbulence. The rush of gas through the opening 15 has a tendency to carry with it the gas in the chamber between baffles 7 and 8 so as to scavenge this chamber before the next pulse of gas arrives. The gas issuing from opening 15 enters the chamber between baffles 8 and 9 wherein expansion, turbulence and scavenging is repeated. Turbulence has the effect of retarding the gases by slowing them down without creating a back pressure thereby reducing the noise level of the impulses, a series of baffles being effective to smooth the impulses into a uniform expulsion of gas from the outlet 3 of the muffler.

In Fig. 7, the baffles 47 through 54 are reversed in operation from those of Fig. 1 but because of the spacing between them, the chambers for permitting sequential expansion, turbulence and scavenging are present and operate in the manner disclosed hereinabove.

The suction effect in the nozzles is obtained when the gases emanating from the nozzles, such as nozzle 56 in Fig. 7, are drawn backward as shown by the arrows as a result of the injector effect produced by the inlet pipe and the nozzle 55 thereby permitting expansion and turbulence of the gases in the space between the nozzles and the muffler casing 1. This has a great attenuating effect on the explosion impulses, and the reexpansion in the several expansion chambers along the route further attenuates not only the pressure pulses but also the noise level, so that by the time the gases reach the outlet, a smooth even flow at a comparatively low pressure is obtained with a very low noise level. A series of air inlets 57, 58 may be used, passing through the inlet plate 59 of the muffler, as shown in this figure, for supplying cooling air. In this case, a conical baffle 56' may be provided to block off the annular space around the nozzle 56 and direct the gases inwardly into the inlet of nozzle 56.

Fig. 8 diagrammatically illustrates a novel form of mufflers which may be used on aircraft engines, where it is exposed to the air stream, so as to obtain the benefit of the suction effect of the air stream 60 to aid in reducing the back pressure caused by the exhaust gases in the muffler on the engine. The muffler casing 61 in this form is gradually enlarged toward the outlet end and has a series of conical nozzles 62, 63, 64, near the inlet 65 followed by a conical baffle 66 converging upstream, annularly spaced from the muffler casing and having a central opening 67 forming the inlet to a conical nozzle 68, and followed by a further series of conical nozzles 69, 70. The outlet 71 of this muffler is formed by a series of diverging conical nozzles 72 to 75 held together by brackets (not shown), so as to form annular opening 76 to 80 between the successive nozzles, the last nozzle being baffled by a conical plug 81 forming therewith the last annular opening 80 and having a conical end 82 for streamlining effect. Thus, in this form, a continuous axial passage is formed for the main flow, there being some reversal of flow only in the expansion chambers by a part of the gases, which are sucked back into the main flow by the nozzle effect of the flow of impulses through the nozzles.

In Fig. 9 another form of muffle, particularly adapted for aircraft use, is shown, having a similar shape and arrangement of the nozzles 83 to 86, but being supplied with a perforated conical baffle 87 near the outlet 88, with its apex 90 turned upstream and the perforations 89 directed in-

wardly toward the apex of the cone. These perforations provide for a suction effect produced by the flow of gases around the outside of the cone, drawing some of the gases from inside the cone outwardly through these perforations into the main flow. These mufflers may also be provided with air inlets 91, 92, as shown, for supplying cooling air, if desired. In this case also a conical baffle 86' may be used to block off the annular passage around the baffle 86. The muffler outlet is formed similarly to that shown in Fig. 8, by a series of diverging nozzles 93 to 96 and the plug 97.

In Figs. 10 and 11, a wet type of muffler is shown, diagrammatically illustrating further modifications in the arrangement of nozzles, baffles and shape of mufflers. The form in Fig. 10 has a series of nozzles 98 to 101 increasing in size from the inlet end toward the outlet, and a conical baffle 102 annularly spaced from the muffler casing 103 with its apex directed upstream, and a water drain 104 at the lowest point in the muffler casing. Fig. 11 shows a muffler similar in shape but using only three conical nozzles 105, 106, 107, at the inlet end, and having a similar conical baffle 108 near the outlet except that it is provided with a central opening 109 forming an inlet to a sleeve 110, and is followed by an additional conical nozzle 111 immediately in front of the muffler outlet 112.

A series of tests have been made on mufflers of this construction, comparisons being made with some standard constructions, and have indicated a marked improvement in reduction of noise level and back pressure as compared with the standard constructions. Obviously the design may be varied to suit the requirements of the particular installation by regulating the size of openings and arrangements and type of baffles in accordance with the desired results, possibly sacrificing some reduction of back pressure to obtain a better attenuation of noise level or vice versa, as may be desired, as is well known, but in any case the next results should show a marked improvement over existing constructions. Thus in the wet type muffler, the dispersion of a controlled amount of water into the muffler may determine the desired reduction in noise level but will also have an opposite effect on the reduction of back pressure at the engine. In the dry type of muffler, the form, arrangement, and size of baffles and nozzles will also have an effect on both noise level and back pressure but it has been found that the arrangements, in general, covered by this disclosure, wherein one or more conical nozzles are used near the inlet end of the muffler combined with one or more conical baffles provide an unusually good arrangement for reducing both noise level and back pressure in any one particular installation as compared with other constructions of mufflers.

Further advantage of the present constructions of baffles in the muffler is that they prevent the harmful back flow of burned gases back into the engine cylinders, as is the tendency in some internal combustion engines under some conditions of low frequency pulses. This is because the baffles present effective obstructions to a reverse flow of gases by reflecting them in the opposite direction, if there should be any back flow started due to an extended low pressure period between impulses at the engine.

Although the drawings illustrate mufflers adapted particularly for use on the exhaust of internal combustion engines, suitable mufflers

made according to this invention may also be designed for use on air intakes for carburetors or in ventilation systems, etc.

One application, to which the present invention lends itself more particularly, is on the exhaust of engines for aircraft using large diameter, low speed propellers which are nearly noiseless, such as some of the helicopter types, some lighter-than-aircraft, etc. Such craft may thus be made almost absolutely noiseless.

Obviously, many other changes in form and arrangement of parts in these mufflers might be made besides those illustrated herein without departing from the spirit and scope of this invention, as defined in the appended claims.

This invention may be manufactured and used by or for the Government of the United States of America for governmental purposes without the payment of any royalties thereon or therefor.

What is claimed is:

1. A muffler for an internal combustion engine composed of an inlet section, a plurality of intermediate sections and an outlet section, each of said sections being enclosed in a cylindrical tubular portion, the several sections being consecutively positioned with the tubular portions forming a single cylindrical casing; said inlet section comprising a tubular portion closed at one end by a plate secured thereto, an inlet pipe for said exhaust gases extending through said plate into said inlet section, a plurality of truncated conical shells consecutively arranged coaxially with said inlet pipe to form a suction channel, one of said shells being disposed with its larger end adjacent the end of said inlet pipe, and successive shells being disposed with their larger ends adjacent the smaller end of the preceding shell, the said tubular portion extending beyond the suction channel thus formed, whereby the exhaust gases passing through the shells cause a circulation of the exhaust gases within said inlet section; each of said plurality of intermediate sections comprising, a tubular portion open at its inlet end and its outlet end, a first baffle composed of a conical shell of apex angle of substantially more than 90° and a maximum diameter substantially smaller than the diameter of the cylindrical portion, said first baffle being coaxially positioned within said portion with its convex surface toward the inlet end thereof and its apex spaced from the said inlet end, and a second baffle composed of a truncated section of a cone having an apex angle of substantially more than 90°, said baffle having an outside diameter substantially equal to the diameter to said tubular portion, said second baffle being coaxially positioned within said tubular portion with its convex surface toward the outlet end thereof, said second baffle being spaced from said first baffle and said outlet end of said tubular portion whereby the exhaust gases passing through said intermediate section cause turbulence within the space between the first and second baffle and on the outlet side of said second baffle; said outlet section comprising a cylindrical portion closed at one end by a plate secured thereto, an outlet baffle composed of a conical shell having an apex angle of substantially more than 90° and a maximum diameter substantially smaller than the diameter of said cylindrical portion, said outlet baffle being coaxially positioned within said cylindrical portion spaced from said open end of said section and from said closed end thereof, and an outlet pipe attached to said plate to conduct said exhaust gases from the muffler.

2. A muffler as described in claim 1 in which said inlet section includes an inlet adjacent said inlet pipe for a cooling medium.

3. A muffler as described in claim 1 in which said inlet section includes an inlet adjacent said inlet pipe for cooling water and the outlet pipe in said outlet section is positioned at the bottom of said outlet section.

4. In a muffler for the exhaust gases of an internal combustion engine, a substantially closed casing having an inlet end, an outlet end, and containing a single chamber, said casing containing a plurality of oppositely disposed conical baffles coaxially positioned within said chamber, an inlet pipe extending through the inlet end of said casing, at least one truncated conical nozzle having a diameter substantially smaller than said casing positioned within said chamber coaxial with and spaced from said inlet pipe and having its larger end adjacent the end of said inlet pipe and spaced from the inlet end of said casing, said nozzle and the baffle adjacent said nozzle defining an expansion chamber therebetween, whereby the exhaust gases passing through said nozzle cause a low pressure area surrounding said nozzle and cause a recirculation of the gases, said plurality of conical baffles being coaxially disposed within said casing between the conical nozzle and said outlet end of said casing with adjacent baffle elements spaced from each other, each pair thereof defining an expansion chamber therebetween in which the gases are subsequently expanded, subjected to turbulence and scavenged therefrom, an exhaust means in the outlet end of said casing for allowing said gases to leave the casing.

5. A muffler as claimed in claim 4 which includes a pipe passing through the inlet end of said casing for injecting water into said conical nozzle, said pipe being angularly disposed relative to said casing to direct said water in a direction substantially parallel to the side of said conical nozzle.

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REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
624,062	Matthews et al.	May 2, 1899
1,061,272	DeWitt	May 13, 1913
1,084,883	Holzwarth	Jan. 20, 1914
1,162,064	Hutton	Nov. 30, 1915
1,169,030	Hardy	Jan. 18, 1916
1,685,701	Blanchard	Sept. 25, 1928
1,760,924	Watkins	June 3, 1930
1,874,326	Mason	Aug. 30, 1932
1,991,014	Compo	Feb. 12, 1935
1,990,837	Morgenstern	Feb. 12, 1935
2,024,834	Rippe	Dec. 17, 1935
2,088,576	Compo	Aug. 3, 1937
2,330,534	Wood	Sept. 28, 1943

FOREIGN PATENTS

Number	Country	Date
19,777	Great Britain	Oct. 4, 1901
128,934	Great Britain	June 24, 1919
380,278	France	Oct. 3, 1907