March 12, 1957 J. H. BAILEY 2,784,797

MUFFLER

Filed July 13, 1954

FIG_1

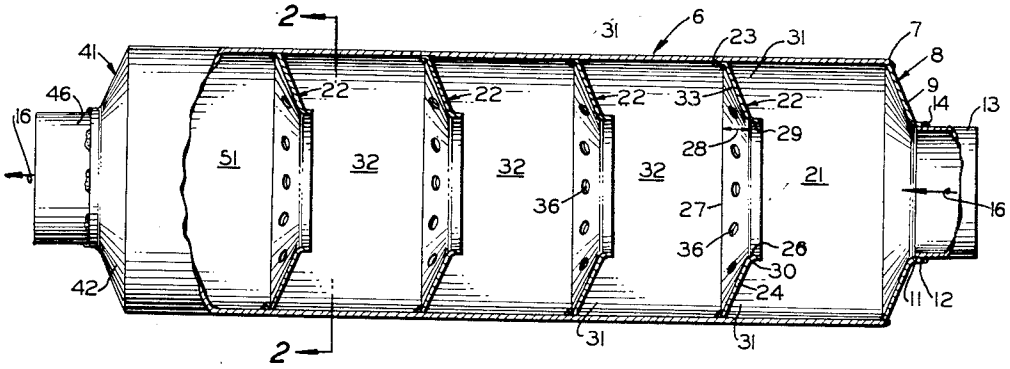
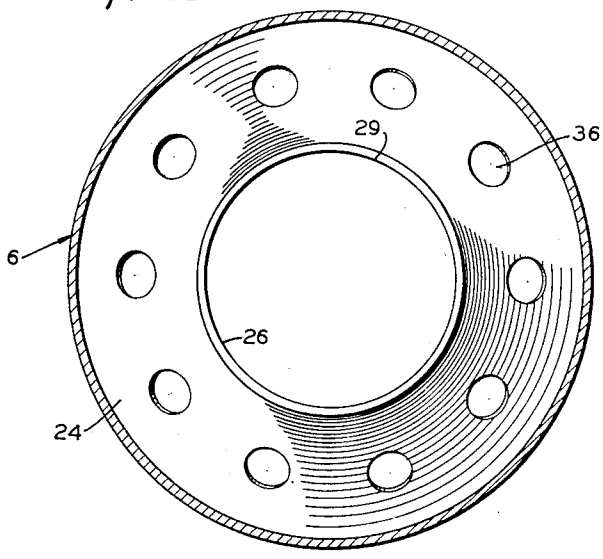


FIG_2



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United States Patent Office

2,784,797

Patented Mar. 12, 1957

2,784,797

MUFFLER

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Application July 13, 1954, Serial No. 442,965

1 Claim. (Cl. 181—47)

This invention relates to improvements in mufflers.

Many thousands of mufflers of the kind shown and described in my co-pending application Serial No. 227,391, filed May 21, 1951, for Baffle Muffler Silencer, now Patent 2,730,188 granted January 10, 1956, have been made, used and sold during the last few years. In certain types of heavy duty installations and under certain extreme conditions of operations, such as incomplete fuel combustion, however, the casing of the foregoing type of muffler has sometimes become overheated, particularly that portion of the casing near the exhaust inlet.

It is therefore an object of the present invention to provide a muffler which under all known installations and operating conditions does not become overheated.

It is another object of the invention to provide a muffler which is extremely effective in lowering the noise level of exhausting gases from internal combustion engines to a marked degree.

It is still another object of the invention to provide a muffler which is economical to manufacture, and easy to install either on original or replacement installations.

It is yet another object of the invention to provide a muffler which even though quiet in operation does not build up an undesirable back pressure in the exhaust system.

It is a still further object of the invention to provide a generally improved muffler.

Other objects, together with the foregoing, are obtained in the embodiment described below and illustrated by the accompanying drawing, in which:

Figure 1 is a side elevation of a small portion of the inlet and the outlet ends, the balance of the muffler being shown in section along a medium vertical plane.

Figure 2 is a section, to an enlarged scale, along the plane indicated by the line 2—2 of Figure 1.

The muffler of my invention is susceptible of numerous embodiments depending on the particular environmental situation to be encountered but the embodiment herein shown and described has been the subject of considerable commercial success, especially in the field of diesel-powered trucks and tractors.

The casing 6, or body, is cylindrical in section and while an elliptical or other cross-sectional configuration is frequently used to meet space limitations, a cylinder of right circular form is here illustrated.

Butt-welded to the front upstream end 7 of the casing is a conical front or upstream plate 8 having sides 9 converging in an outer or upstream direction and terminating in a central opening 11 from which projects an outwardly extending sleeve 12 to receive the engine exhaust pipe, or muffler intake pipe, 13 and to which it is secured by appropriate fastenings, such as weldments 14.

The exhaust gases enter through the inlet pipe 13 in a downstream direction indicated by the arrow 16, the gases being at a high temperature and entering the muffler in a rapid series of noisy pulses of greater and less pressure. Owing to the lateral confinement of the gases effected by the pipe 13 during travel from the exhaust manifold to the muffler it might be considered that the gas leaves the pipe 13 in the form of a cylindrical stream or column.

The primary purpose of a muffler is to silence the noise made by the exhaust gases, silencing being effected variously, as by breaking up or damping the periodic pulses and extracting the energy residing in the gas stream so that when the exhaust gases are discharged into the atmosphere the sound waves are of acceptable frequencies and below permissible intensities.

As the gas column enters through the central opening 11, it encounters a first chamber 21 bounded peripherally by the adjacent walls of the casing 6 and on the upstream end by the sloping front plate sides 9. Owing to the sharp outward and downstream slope of the sides 9, the outer "layers" of the entrant gas column, under elevated temperature and pressure, suddenly expand outwardly, rushing and whirling along the sides 9, thence into abutment with the contiguous casing walls and forwardly along those walls. The casing walls act as a cooling and heat transferring media, a highly important function in the first chamber 21 since the exhaust gases are not only hottest at this point, but, in some instances, for example where incomplete fuel combustion has taken place, the chamber must dissipate the heat generated by the combustion of previously unconsumed fuel.

Subjacent gas "layers" in the column partake of the same kind of expansion, heat dissipation and current diffusion, but to a lesser degree. An innermost "core" of the column of gases probably expands outwardly only to a limited extent, the innermost core assuming as it progresses downstream perhaps a cone-shaped stream (when viewed in elevation and plan) with the sloping sides of the "cone" diverging only slightly as the gas moves downstream.

Serving to deflect and reverse and set up energy-dissipating eddy-currents in the outer layers of the gas (and which has already been deprived of some energy by expansion into the chamber 21 and cooling contact with the sides 9 and casing walls), is a baffle plate 22 mounted within the casing and circumferentially welded thereto as by a weldment 23, the weldment extending around the entire periphery for maximum heat conductivity. The baffle plate has sides 24 which extend inwardly from the casing walls and converge in an upstream direction, terminating in a central circular opennig 26. The slope of the sides is at a sharp angle with respect to the casing walls, the diameter 27 of the plate base being at least five times the height 28 of the sides 24 measured normal to the cone's base. Not only does the steep slop of the sides effect a sharper reversal of the gases impinging thereon than would a low slope, but the steepiness of the slope causes the length of travel to heat to be shorter (from any heated point on the side to the lower temperature existing at the outer perimeter of the side) than would be the case were the side to have a long, low slope.

Not only is the baffle plate capable of acting on the outer layers of the gas column and which have expanded outwardly into the chamber 21 and along the walls but it also serves an important purpose with respect to the cone-shaped "core" of gases. Extending in an upstream direction from the perimeter of the central opening 26 is a stiffening and deflecting sleeve 29 or lip, substantially circular cylindrical in section and being faired or curved smoothly into the upstream of the sloping sides.

The sleeve 29 prevents distortion of the plate under thermal stresses and markedly reduces vibration or fluttering of the plate resulting from impingement of the gas stream and especially from resonant vibration induced by gas pulses having a frequency near the natural fre-

quency of the muffler or its components such as the baffle plates.

Furthermore, the sleeve 29 intercepts and deflects or diverts in an outward or lateral direction all that portion of the gas "cone" located radially outwardly from the sleeve itself, and simultaneously causes the gas particles passing through or within the sleeve to assume a cylindrical or columnar shape, somewhat in a similar fashion to the gas cylinder or column created by the inlet pipe 13.

The laterally deflected gas diverted outwardly by the sleeve 29 continues, by inertia, to move in a downstream direction until it strikes the steeply sloping sides 24 and is broken up into whorls and eddy currents which traverse outwardly and across the surface of the sides toward the casing walls, the gas becoming cooled by contact with the plate sides which act as cooling fins, and by dissipation of energy in eddying. Adjacent the casing walls the deflected gas currents become even more turbulent as they meet the gas currents from the outer "layers" which had previously expanded laterally into the chamber 21, had traversed the sides 9 and swept along the casing walls in a downstream direction. So violent is the turbulence in this corner pocket 31 that it is believed some of the whorls extend inwardly so far as to reach and rejoin the gas stream entering and flowing through the sleeve 29 and central opening or aperture 26, and thus imparting to that stream a significant magnitude of cross or lateral currents causing that stream to become even more unstable, and enhancing the tendency of the "core" of gas entering a second chamber 32 to expand rapidly into that chamber and to flow outwardly along the downstream surfaces 33 of the sides 24 into impingement with the casing walls and along those walls in a downstream direction, resulting, as before, in the creation of energy-dissipating eddy currents and consequent cooling of the gas.

It is highly desirable that a muffler not only reduce the exhaust gas noise but that it also offer such low resistance to gas flow that excessive back pressure is not created. The provision in the muffler of my invention of a plurality of apertures 36, or openings, or through holes, in the sides 24 of the baffle plate accomplishes both of these desirable results and to an admirable degree. The apertures, preferably 10 in number, are conveniently circular and have a diameter approximately one-sixth to one-seventh the diameter of the central opening 26, the centers of the apertures being located at a position substantially midway on a radial line between the opening 26 and the casing walls.

At least a two-fold effect seems to be imparted by the apertures. As the eddying gas currents, deflected laterally by the sleeve 29 and its smoothly fairing root portion 30, sweep over the apertures 36, portions of the gas swirl through the apertures and into the second chamber 32. This flow through the apertures not only lessens the building up of pressure in the pockets 31, and so reduces back-pressure, but it also breaks up even more the currents traversing outwardly along the downstream faces 33 of the plate sides 24, resulting in increased energy dissipation and consequent noise reduction. It is believed, furthermore, that the flow of gas along the downstream face 33 causes a certain amount of "draw," as by an injection effect, causing flow of gas from the upstream face to the downstream face of the plate through the apertures. Increased gas turbulence on both the upstream and downstream faces results with localized turbulences reducing, it is believed, the tendency of the gases to cause hot-spots on the plates and casing walls, it being a matter determined by extensive tests and road trials that the muffler casing of this muffler stays well within desired temperature levels.

Additional baffle plates 22 substantially identical with the above-described plate are mounted within the casing and forming corresponding chambers 32. The plate apertures 36 in adjacent plates are not necessarily in register. Any desired number of plates may be used, each additional plate serving to reduce the noise but increasing somewhat the back pressure. It has been found by exhaustive trials, that the use of four baffles gives optimum results in most mufflers, even where the mufflers vary from two to four feet in length and the diameter from seven to nine inches.

Capping the downstream end of the casing is a rear or downstream plate 41 welded to the casing and having its sides 42 converging sharply in a downstream direction to terminate in a central opening encircling an outlet pipe 46 and which conducts the muffled and silence exhaust gases into the atmosphere. Formed between the most downstream one of the baffle plates 22 and the rear plate 41 is a final expansion, cooling and energy dissipating chamber 51 larger in volume than the previous chambers 21 and 32 owing to the oppositely disposed slopes of the bounding plates, the plate 42 converging in a downstream direction. The increased volume and the different configuration of the chamber 51 serves to extract substantially all of the residuum of exhaust gas energies above permissive temperature and noise levels, the gases then being discharged into the atmosphere in a state well within the legal requirements in all jurisdictions.

What is claimed is:

A muffler comprising a thin-walled circular cylindrical casing having mounted on its opposite ends a front upstream frusto-conical plate of thin-walled material converging in an upstream direction and terminating in a short cylindrical mounting sleeve for attachment to an exhaust inlet pipe and a rear downstream frusto-conical plate of thin-walled material converging in a downstream direction and terminating in a short cylindrical mounting sleeve for attachment to an outlet pipe said muffler further comprising a plurality of thin-walled frusto-conical baffle plates mounted within said casing, each of said baffle plates having inclined sides extending from said casing and sloping inwardly and in an upstream direction to define a central circular opening approximately one-half the diameter of said casing, said casing diameter being at least five times the height of said baffle plate measured normal to its base, each of said sides having formed therein a plurality of perforations located at equal radii from the longitudinal axis of said casing and approximately midway between said central circular opening and said casing, each of said perforations having a diameter such that the total area of said perforations is 0.2 to 0.3 the area of said central circular opening, and a plurality of thin-walled sleeves mounted on and arcuately faired into each of said baffle plates at the margins of said central openings, each of said sleeves projecting in an upstream direction from said opening and concentric with said upstream and said downstream mounting sleeves smoothly to divert in a lateral direction a predetermined portion of the exhaust gases approaching said plate and direct said diverted gases across said perforated sides and toward said casing.

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