United States Patent

Rowley et al.

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[54] MUFFLER FOR INTERNAL COMBUSTION ENGINE

[72] Inventors: **Douglas W. Rowley**, St. Paul; **John A. Campbell**, Minneapolis, both of Minn.

[73] Assignee: **Donaldson Company, Inc.**, Minneapolis, Minn.

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[52] **U.S. Cl.** .....**181/44**, 181/47 R

[51] **Int. Cl.**.....**F01n 1/00**

[58] **Field of Search** .....181/44, 47 R, 48, 63, 46, 57, 181/59, 41, 49

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Primary Examiner—Richard B. Wilkinson
Assistant Examiner—John F. Gonzales
Attorney—Merchant & Gould

[57] **ABSTRACT**

A muffler for internal combustion engines which employs a converging-diverging nozzle and a length of perforated tubing to effect sound attenuation with minimum back pressure. The perforated tube is axially disposed in a cylindrical casing, projecting forwardly from the muffler outlet and defining alternate flow passages. The nozzle member is disposed in the perforated tube, its mouth positioned at the tube inlet and spaced downstream from the muffler inlet. An imperforate baffle disposed in the annular passage between the perforated tube and cylindrical casing intermediate the ends of the nozzle member lengthens the passage with respect to the alternate, causing the divided gas flows to travel different distances prior to recombination and exhaust.

6 Claims, 3 Drawing Figures

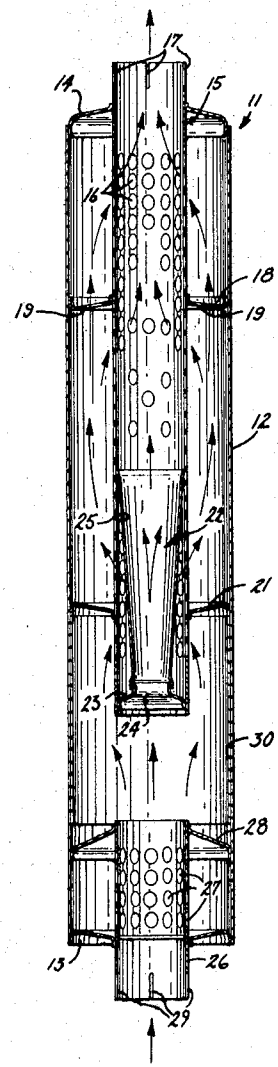


FIG. 1

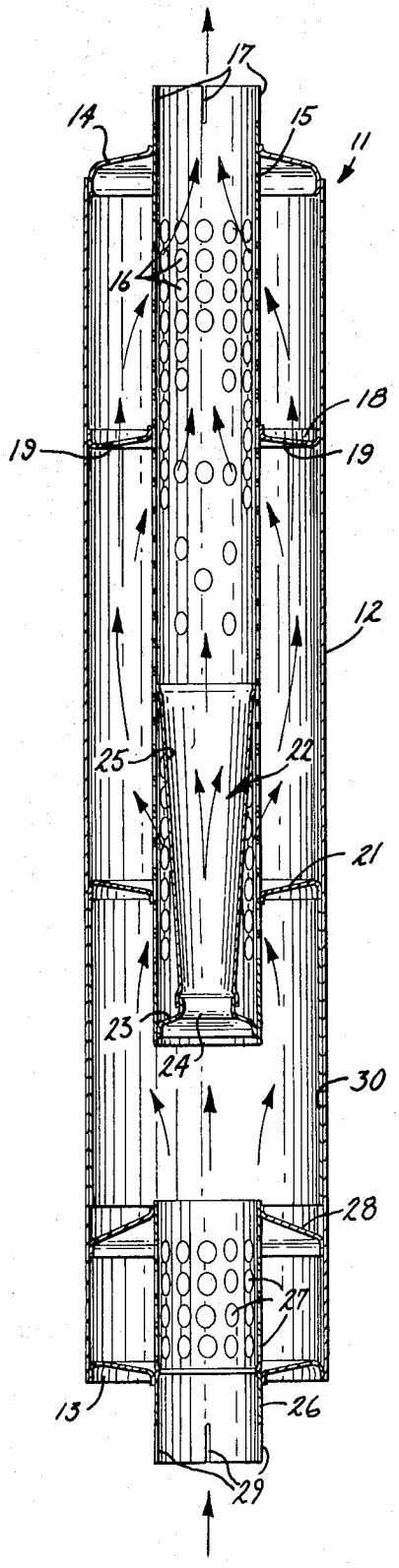


FIG. 2

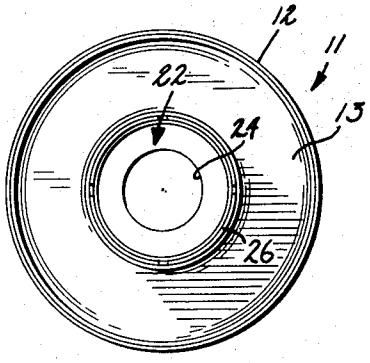
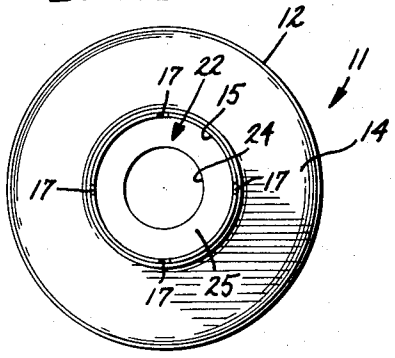


FIG. 3



INVENTORS
JOHN A. CAMPBELL
DOUGLAS W. ROWLEY
BY
Merchant & Gould
ATTORNEYS

MUFFLER FOR INTERNAL COMBUSTION ENGINE

The invention is directed to mufflers for internal combustion engines in which sound attenuation is effected with a minimum of back pressure.

The preferred embodiment of the invention consists of a cylindrical casing defining a longitudinal chamber and having an inlet and outlet. A perforated tube of lesser length than the cylindrical casing is axially and concentrically disposed therein, projecting forwardly from the casing outlet and supported by one or more baffles. As described, the casing and perforated tube define a pair of alternating flow passages (which communicate by virtue of the perforations), one through the tube and one in the annular area defined between the tube and casing.

Disposed in the perforated tube at its inlet is an imperforate convergent-divergent nozzle member the mouth of which is spaced from the muffler inlet. The divergence of the nozzle member downstream of its throat is gradual to decrease boundary layer separation as flow decelerates.

An imperforate tube-supporting baffle disposed intermediate the ends of the nozzle member fully blocks the annular passage, thus causing the exhaust gases entering that region to pass inside the perforated tube upstream of the baffle, along the outer surface of the nozzle member and out from the tube into the annular passage beyond the baffle. The nozzle member is shorter than the perforate tube so that the exhaust gases passing through the alternate flow paths can recombine prior to exhaust through the muffler outlet.

We have found that the structure described above is extremely effective in attenuating sound generated by an internal combustion engine while keeping back pressure, which hampers efficiency of the engine, to a minimum. We believe the reasons for this performance to be at least twofold:

(1) The acoustical impedance of the nozzle throat is greater than that at the nozzle mouth. Consequently, a portion of the sound waves attempting to enter the nozzle member are reflected back, thereby reducing the sound level. (2) By reason of the imperforate baffle, the annular flow passage is longer than the nozzle-tube flow passage. Consequently, upon recombination of gases at a point downstream of the nozzle the sound waves carried in the medium of the respective exhaust gas flows are out of phase with respect to each other, and cancellation further reduces the sound level.

The sound attenuation is not done at the expense of an extensive pressure build-up within the muffler. "Straight through" construction, which arises from axial and concentric disposition of the nozzle member and perforated tube with respect to the muffler inlet and outlet, presents a minimum resistance to exhaust gas flow. Further, the diverging portion of the nozzle member tapers gradually to decrease flow separation, thus preserving the continuous and steady flow characteristic necessary for minimum pressure build-up.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a longitudinal sectional view of a muffler embodying the inventive principle;

FIG. 2 is an end view of a muffler as viewed from the muffler intake; and

FIG. 3 is an end view of a muffler as viewed from the muffler exhaust.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to the figures, a muffler intended for use with internal combustion engines and embodying the inventive principle as represented generally by the numeral **11**. Muffler **11** consists of a cylindrical casing **12** of predetermined length having annular end caps **13** and **14** which respectively define the muffler inlet and outlet.

A tube **15** is axially and concentrically disposed in casing **12**, its outlet end being sealably affixed to end cap **14**, as by welding, and its inlet end spaced from the muffler inlet a predetermined distance. Tube **15** has a plurality of perforations **16** extending over the major portion of its length, all of which lie within casing **12**. The outlet end of tube **15** may be slit, as at **17**, for connection to a tailpipe.

Tube **15** is supported internally by a first annular baffle **18** which includes a plurality of perforations **19**, and a second annular baffle **21** which is imperforate. Baffle **21** is constructed and arranged to block the annular passage defined by tube **15** and casing **12**.

Disposed within tube **15**, commencing at its inlet end and projecting rearwardly therefrom, is a nozzle member **22** having an abruptly tapering converging portion **23**, a throat **24** and a diverging portion **25** which tapers gradually into engagement with the inner surface of tube **15**. Nozzle member **22** is imperforate, and as best shown in FIG. **1**, baffle **21** is disposed at a point intermediate its ends. Thus, the flow of exhaust gases entering the annular passage are forced inside tube **15** upstream of baffle **21** (as represented by the arrows), and back out of tube **15** downstream of baffle **21**. Thus, it is apparent that exhaust gases entering the annular passage must necessarily take a longer journey than those passing directly through nozzle member **22** and tube **15** prior to recombination downstream of the nozzle outlet.

Disposed in the muffler inlet is a tube **26** which is of the same size as tube **15** and is disposed in axial alignment therewith. Tube **26** is also formed with a plurality of perforations **27**, all of which lie within cylindrical casing **12**, and is given support by end cap **13** and another annular support member **28**. The inlet end of tube **26** may include one or more slits **29** to facilitate connection of muffler **11** to an exhaust pipe.

The size, shape and arrangement of the constituent parts of muffler **11** are chosen so that the flow of exhaust gases entering tube **26** is divided as evenly as possible between the longer annular passage and the passage through nozzle **22** and tube **15**. Thus, the flow of exhaust gases through perforations **27** of tube **26** into the dead end chamber defined by end cap **13** and support member **28**, which assists in the attenuation of sound to a limited degree. That portion of the flow proceeding directly to nozzle member **22** is caused by portion **23** to converge upon throat **24**, at which point it attains its maximum velocity and lowest static pressure. The flow then proceeds in a smooth pattern by virtue of the gradual divergence of portion **25** and continues on through tube **15**. A portion of the sound waves existing in the gaseous medium, however, are prevented from passing through throat **24** by virtue of the increased acoustical impedance encountered at that point. A portion of the waves are reflected back, which serves to significantly attenuate the sound level.

The remaining portion of exhaust gas flow passes through the longer annular passage, and, at a point downstream of the outlet of imperforate nozzle member **22** begins to recombine with the flow that has moved through nozzle **22** and into tube **15**. The sound waves carried through the alternate flow passage, in seeking their paths of least resistance, must also journey further before the recombination. As a result, the sound waves moving through the alternate passages are out of phase by the time they reach a point of recombination, thus effecting a significant wave cancellation and further attenuation of sound. The result is a substantial decrease in the sound level emanating from the internal combustion engine.

By virtue of the "straight through" construction and the gradual taper of diverging portion **25**, the flow of exhaust gases, whether through the central or annular passage, encounters minimum fluid resistance. Thus, the back pressure which hampers operating efficiency of the internal combustion engine is kept to a minimum while sound attenuation takes place.

As can be readily observed, the structure which permits this desirable operation is extremely simple and comprises a minimum number of parts. This is due in large part to the unique disposition of nozzle member **22**, which not only attenuates sound and preserves laminar flow, but also defines with baffle **21** a portion of the longer annular passage which effects the downstream cancellation of out of phase sound waves.

What is claimed is:

1. A muffler comprising:

a housing defining a longitudinal chamber having an inlet and an outlet;

a perforated tube disposed in substantial axial alignment with the chamber inlet, the perforated tube having an inlet end spaced a predetermined distance from the chamber inlet and an outlet end communicating directly with the chamber outlet;

an imperforate nozzle member disposed in the perforated tube, the nozzle member having a mouth generally conforming to and disposed at the inlet end of the tube, and a portion converging to a throat and a portion diverging from the throat to an outlet conforming to the perforate tube;

and an imperforate baffle disposed in the passage between the perforated tube and the housing intermediate the ends of the nozzle member, the baffle constructed and arranged to divert the flow of exhaust gases between the outer surface of the nozzle means and the perforated tube.

2. The muffler as defined by claim 1, wherein the housing, the perforated tube, the nozzle member and the imperforate baffle are circular in shape and concentrically disposed.

3. The muffler as defined by claim 1, wherein the constituent parts of the muffler are constructed and arranged to divide flow through the passage between the perforated tube and the housing and the passage through the nozzle member essentially equally.

4. The muffler as defined by claim 1, and further comprising a second perforated tube having an inlet end and an outlet end, the second perforated tube being of the same size as the first claimed perforated tube and disposed in spaced axial alignment therewith, the inlet end of the second perforated tube communicating directly with the chamber inlet and the outlet end being supported within the housing by an imperforate member.

5. The muffler as defined by claim 1, wherein the divergent portion of the nozzle member tapers more gradually than the converging portion.

6. The muffler as defined by claim 1, wherein the imperforate baffle supports the perforated tube within the housing.

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