Sept. 10, 1935. L. R. HEATH 2,013,956

MUFFLER

Filed Nov. 16, 1931 3 Sheets-Sheet 1

Fig. 1.

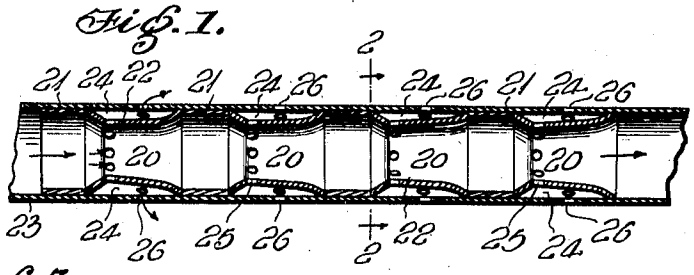


Fig. 2.

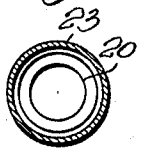


Fig. 3.

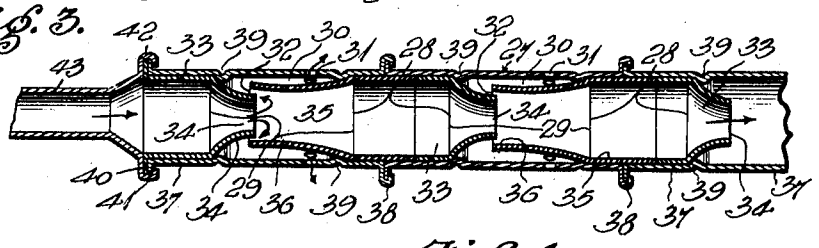


Fig. 4.

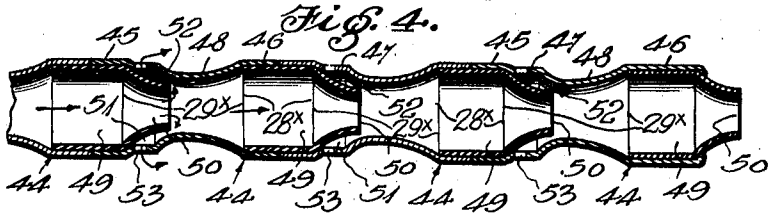


Fig. 5.

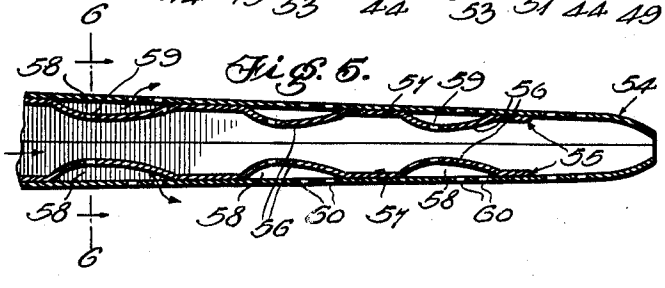


Fig. 6.

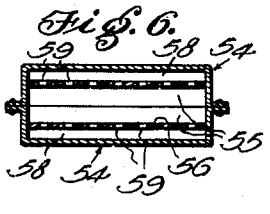
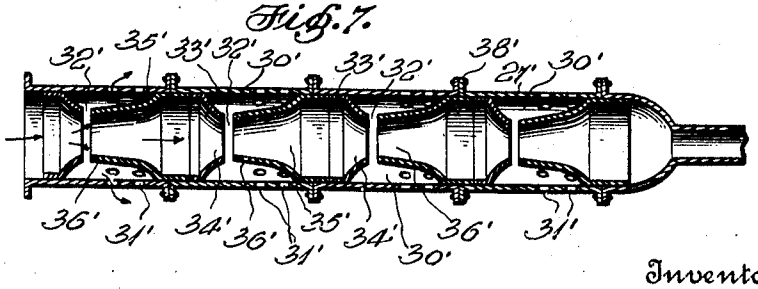


Fig. 7.



Inventor

L. R. Heath

Witness

A. Woodard

By H. B. Williamson

Attorneys.

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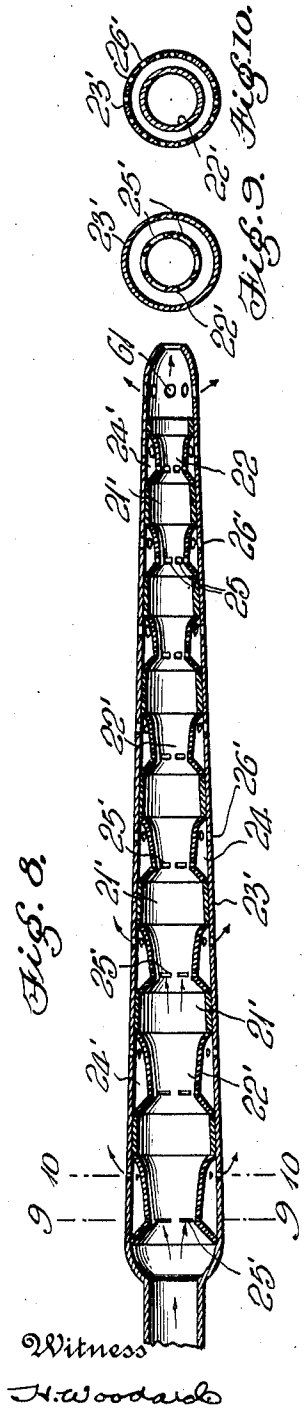

Fig. 8.

Fig. 9.

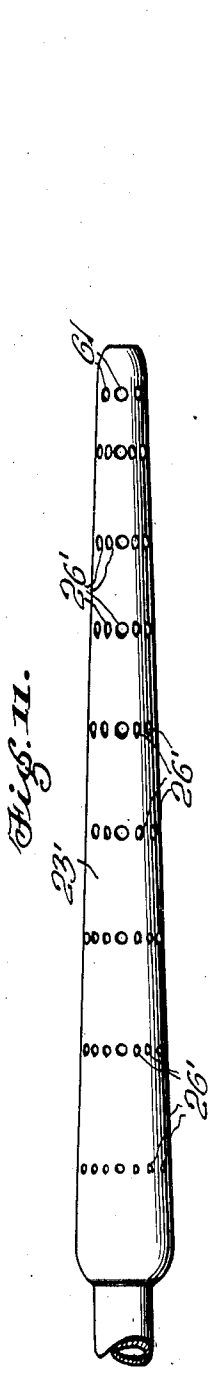

Fig. 11.

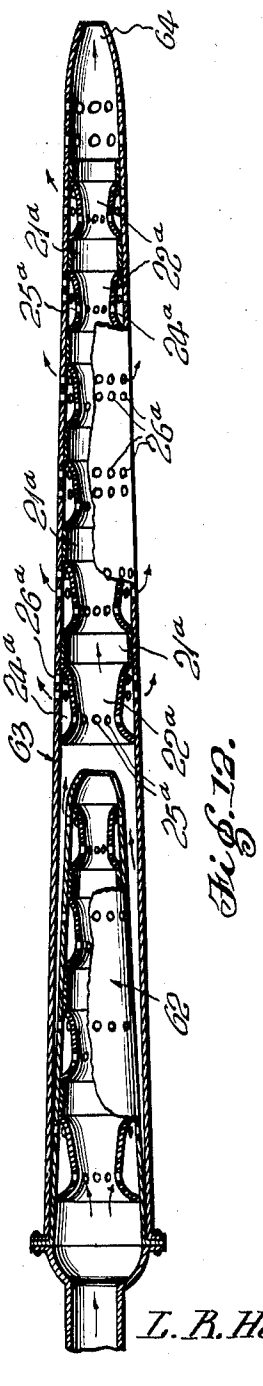

Fig. 12.

Witness

H. Woodard

Inventor

L. R. Heath

By H. B. Williamson & Co

Attorneys.

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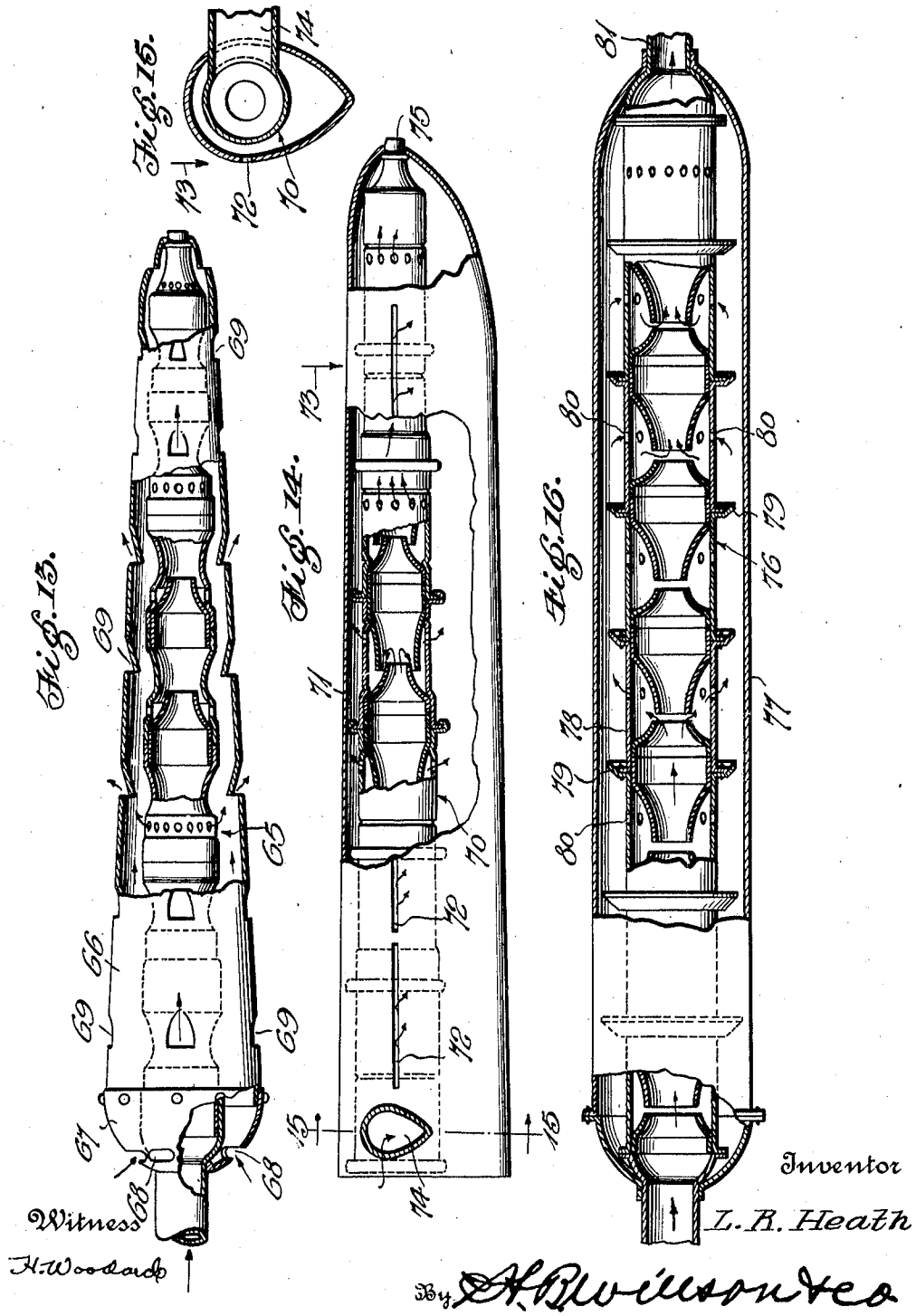

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UNITED STATES PATENT OFFICE

2,013,956

MUFFLER

Laurence R. Heath, Sterling, Ill.

Application November 16, 1931, Serial No. 575,437

8 Claims. (Cl. 137—160)

The invention relates to improvements in mufflers and more particularly to those adapted for use with internal combustion engines.

The principal object of the invention is to provide a muffler which may be easily and inexpensively manufactured and which will effectively diffuse the gas quietly and without back pressure. The arrangement is such that the flow of gas is not interrupted by eddy currents and the characteristic pulsating exhaust of the internal combustion engine, is greatly reduced, both by cooling and the application of well known aerodynamical principles.

A further object of the invention is to provide a construction which may if desired, be employed within an enveloping jacket, in which part of the gases after being influenced by the interior construction of the muffler, are collected and from which they are either discharged into the air by their expanding force, aided in escaping by the dynamic reaction of the air flow around the casing, or withdrawn back into the central conduit of the muffler before being discharged. The enveloping jacket is to be provided in forms which best adapt themselves to conditions and requirements of any particular engine installation, whether automotive, aeronautical or stationary.

With the foregoing in view, the invention resides in the novel subject matter hereinafter described and claimed, description being accomplished by reference to the accompanying drawings.

Fig. 1 is a central longitudinal sectional view through a portion of a muffler constructed in accordance with the invention.

Fig. 2 is a transverse sectional view on line 2—2 of Fig. 1.

Fig. 3 is a fragmentary longitudinal sectional view showing a different form of construction.

Fig. 4 is a fragmentary longitudinal section showing a still further form of construction.

Fig. 5 is a longitudinal section illustrating a substantially flat construction whereas the other forms are of annular cross section.

Fig. 6 is a transverse sectional view on line 6—6 of Fig. 5.

Fig. 7 is a fragmentary longitudinal section showing yet another form of construction.

Fig. 8 is a longitudinal sectional view of a complete tapered muffler constructed in a manner very similar to that shown in Fig. 1.

Figs. 9 and 10 are transverse sectional views on lines 9—9 and 10—10 respectively of Fig. 8.

Fig. 11 is a side elevation of the muffler shown in Fig. 8.

Fig. 12 is a longitudinal sectional view partly in elevation showing a two-stage muffler.

Figs. 13 and 14 are elevations partly in section showing two forms of mufflers well suited for aircraft.

Fig. 15 is a transverse section on line 15—15 of Fig. 14.

Fig. 16 is a longitudinal sectional view partly in elevation illustrating yet another form of construction.

In the form of construction shown in Figs. 1 and 2, a gas conduit is provided having a plurality of longitudinally spaced axially alined cylindrical portions 21 which enlarge the conduit both externally and internally, said conduit also having a plurality of longitudinally spaced axially alined Venturi-like portions 20 which decrease the diameter of the conduit both internally and externally between the enlargements. Tubular means, in the form of a sleeve 23, snugly surrounds the cylindrical portions 21 and co-acts with the exteriors of the Venturi-like portions 20 in providing annular pockets 24. Substantially at their smallest diameters, these Venturi-like portions are provided with auxiliary portage 25 from their interiors into the pockets 24, and the sleeve 23 is formed with auxiliary openings 26 extending from said pockets 24 to its exterior.

In order to maintain low back-pressure, the passage through the Venturi-like portions of the conduit should be streamlined as much as possible and the throats should not be unduly restricted. Well proportioned Venturi-like tubes will not materially retard the flow of a gas through them, although the gas velocity is increased and the pressure decreased at the tubes' smallest diameter.

This characteristic reaction is used with great effectiveness in the present muffler, especially during the passage of the high-pressure part of the pulsating exhaust gas discharge. As the pulsating exhaust gases pass through the first several Venturi-like portions 20 of the conduit, part of the gas from each succeeding high-pressure wave peak, expands and escapes under reduced pressure in the direction of the arrows and is diffused by passing through auxiliary ports 25, pockets 24 and openings 26 into the atmosphere. The high pressure wave peaks, at this stage, are of too great an intensity to be entirely neutralized by the Venturi tube's reaction. The result is that part of each high-pressure wave is discharged through the auxiliary ports and openings at a lessened pressure, hence less noisily. Should there be a sufficient number of Venturi-like formations, the high-pressure wave peak will be materially re-

duced by dissipation and cold air will be drawn substantially continuously into the conduit through the last few auxiliary ports and openings provided. It is also conceivable that during the passage of the low-pressure part of the wave through the Venturi-like formations, air may be drawn through the auxiliary openings into the conduit.

The operation as described serves to effectively smooth out the exhaust pulsations within the conduit without excessive back-pressure.

Insofar as the specific structure of the conduit of Figs. 1 and 2 is concerned, it preferably consists of a plurality of separate Venturi tubes upon which the numbers **20** have been placed, and spacing tubes between and abutting the ends of said Venturi tubes. The intermediate portions of the Venturi tubes form the restrictions **22** and the ends of said Venturi tubes and the spacing tubes form the swells **21**.

In the form of construction shown in Fig. 3, a plurality of longitudinally spaced axially alined cylindrical conduit portions **28** are provided, and a plurality of Venturi-like conduit portions **29** are provided between and in axial alinement with said cylindrical conduit portions **28**, said Venturi-like conduit portions **29** having enlarged ends in unobstructed communication with said cylindrical conduit portions **28** and being contracted between their ends. Tubular means, in the form of a sleeve **27**, snugly surrounds the cylindrical conduit portions **28** and co-acts with the contracted portions of the Venturi-like conduit portions **29**, in forming pockets **30**. The conduit portions **29** are provided between their ends with auxiliary portage **32** placing their interiors in communications with the pockets **30**. Perforations **20** are formed in the sleeve **27**, placing the pockets **30** in communication with the atmosphere.

The conduit in Fig. 3 is formed from a plurality of short tubes **33** having contracted ends **34** disposed toward the outlet end of the muffler, and a plurality of additional short tubes **35** abutting the tubes **33** and having reduced ends **36** disposed toward the intake end of the muffler, the tube ends **34** being received within and spaced from the tube ends **36** to provide the Venturi-like portions **29** and the annular ports **32**.

The sleeve **27** is preferably formed from sections **37** crimped or otherwise secured together at **38**, said sections having inwardly pressed ridges **39** abutting the tubes **33** and **35** at the juncture of their reduced ends with the larger portions of the tubes, thereby holding the latter tightly in position. The first tube **33** is preferably provided with a lateral flange **40** lying against a similar flange **41** on the first sleeve section **37**, these flanges being secured together by crimping a portion **42** of the exhaust pipe **43**, around them.

The structure illustrated in Fig. 3 functions in the same manner as that disclosed in Fig. 1.

The nozzle-like throats **34** of Venturi-like portions **29** are structural and do not materially affect the pressure recovery ratio, inasmuch as the diverging discharge tubes **35** streamline the passage and reduce turbulence.

In Fig. 4, the muffler embodies a plurality of short axially alined tubes **44** each having two cylindrical end portions **45** and **46**, a perforated step portion **47** at the inner extremity of the end portion **45**, the perforations of said step portion being shown at **53**, and a restricted portion **48** from said step portion **47** to the end portion **46**. These tubes **44** are disposed in abutting end-to-end relation, and a plurality of additional short tubes **49** are snugly fitted and secured in the adjacent ends of said tubes **44**. Each of the tubes **49** is provided with a contracted end **50** extending within the perforated step portion **47** and one end of the restricted portion **48** and spaced from the latter. The cylindrical portions of the tubes **49** provide longitudinally spaced cylindrical conduit portions **28×** and the tube portions **48** and **50** co-act in forming axially alined Venturi-like conduit portions **29×** between said cylindrical conduit portions **28×**. The steps **47** constitute tubular means surrounding the parts **50** of the Venturi-like portions **29×**, said tubular means co-acting with said parts **50** in forming annular pockets **51**. These parts **50** are spaced from the tube portions **48** to form annular auxiliary portage **52** from the interiors of the Venturi-like conduit portions **29×** into the pockets **51**, and perforations **53** in the annular means **47** place said pockets in communication with the atmosphere.

Moreover, this structure functions in the same way as above described.

A substantially flat, transversely rectangular muffler is shown in Fig. 5, embodying a two-section sleeve **54** and two bent metal strips **55** secured within said sleeve. These strips are bent to provide airfoils **56** spaced apart by straight strip portions **57**, providing the conduit with alternate swells and restrictions and being hence the equivalent of a series of Venturi tubes. The airfoils **56** co-act with the sleeve **54** in providing pockets **58** into which gas from the high pressure wave peak may flow through the auxiliary ports **59** and from which it may discharge through the openings **60** or into which air may flow through openings **60** and from which it may be drawn into the conduit through said auxiliary ports **59**.

In Fig. 7, the construction is very similar to that illustrated in Fig. 3, the alternate restrictions and swells in the diameter of the gas conduit being provided by abutting tubes **33'** and **35'** having contracted ends **34'** and **36'** respectively which are spaced apart longitudinally of the muffler to provide the auxiliary ports **32'**. The sleeve **27'** snugly holds the abutting tubes and co-acts with the restrictions of the conduit in providing pockets **30'** from which openings **31'** are provided. The sleeve **27'** is in sections, suitably secured together at **38'**. When a tail-pipe is used as illustrated, the auxiliary gas discharge is more continuous depending upon the amount of restriction offered.

The structure shown in Figs. 8 to 11 is very similar to that shown in Figs. 1 and 2, the conduit being composed of Venturi tubes **22'** spaced apart by spacing tubes **21'**. The abutting tubes are snugly fitted and held within a tapered sleeve **23'** which co-acts with the restrictions of the conduit in providing gas conducting pockets **24'**. Gas conducting slots **25'** formed in the Venturi tubes **22'**, lead to the pockets **24'**, and openings **26'** in the sleeve **23'**, lead from said pockets. By preference, the slots or the like **25'** increase gradually in width toward the discharge end of the muffler, and the diameters of the openings **26'** increase gradually toward said muffler end. Beyond the last spacing sleeve **21'**, the sleeve **23'** is preferably contracted as shown and provided with gas discharge perforations **61**. In the tapered form shown, the auxiliary gas discharge is increased especially at the larger end of the muffler—the amount depending upon the rate of taper and the degree of restriction at the smaller end.

In Fig. 12, the assemblage 62 is practically identical with that shown in Fig. 8, but shorter, said assemblage being received in the larger end of a tapered sleeve 63 and being inwardly spaced from said sleeve. The portion of the sleeve 63 between the assemblage 62 and the delivery end 64 of said sleeve, is occupied by Venturi tubes 22a and spacing tubes 21a providing alternate swells and restrictions. The restrictions co-act with the sleeve 63 in providing pockets 24a having perforations 25a and 26a, gas-receiving pockets 24a to which perforations 25a extend and from which additional perforations 26a lead to the exterior of the sleeve. The similarity of the assemblage 62 to the construction shown in Figs. 1 and 8, will be obvious, and the existing analogy between the structure 21a, 22a, etc. and Figs. 1 and 8, will also be clear.

The structure of Fig. 12 provides a two-stage muffler which is well adapted to unusually noisy engines or to installations requiring unusual quieting of the exhaust gases.

In Fig. 13, an assemblage 65 constructed in the manner shown in Fig. 4, is centrally secured in a longitudinally tapered jacket sleeve 66, said sleeve 66 having a dome-like front end 67 provided with air inlets 68 and being provided at longitudinally spaced points with inwardly stamped portions providing gas outlets 69. The stream-line type of this form of muffler and the fact that the rush of air around the same will assist in causing discharge of exhaust gases, readily adapt it for use on aircraft.

In Figs. 14 and 15, an assemblage 70 constructed as illustrated in Fig. 3, extends longitudinally within a transversely-stream-lined jacket sleeve 71 which is closed at both of its ends and provided with gas escape slots 72 (or if desired, with series of perforations). The slots or the like 72 are so located that the rush of air against the sleeve 71 in the direction of the arrows 73, causes the creation of outward suction through said slots or the like, assisting in withdrawing the gases from the muffler. The gas inlet 74 extends into the conduit through one side of the jacket sleeve 71 and the tail end of the assemblage 70 is preferably reduced as denoted at 75, and open to the atmosphere.

In Fig. 16, an assemblage 76 constructed as illustrated in Fig. 7, extends longitudinally within a jacket sleeve 77 which is imperforate and closed at both of its ends. The sleeve 78 of the assemblage 76 is provided with annular baffles 79 between its gas-conducting openings 80, said baffles inclining toward the jacket sleeve 77 and terminating in spaced relation with the latter. From the openings 80 toward the intake end of the muffler, exhaust gases discharge into the space between the sleeves 78 and 77. At the delivery end of the muffler, the Venturi throats are of less diameter than those at the intake end so that the gases previously discharged into said space are returned into the conduit by suction and discharged through the final outlet 81. From the openings 80 toward the intake end of the muffler, exhaust gases discharge into the space between the sleeves 78 and 77, but toward the delivery end of the muffler, the pressure of the gases within the conduit becomes so reduced, that the gases previously discharged into said space, are returned into the conduit by suction and discharged through the final outlet 81.

It will be seen from the foregoing that most forms of the invention comprise a straight tubular gas conduit having longitudinally spaced axially alined cylindrical portions which enlarge the diameter of the conduit both internally and externally, said conduit also having longitudinally spaced axially alined Venturi-like portions between said cylindrical portions which decrease the diameter of the conduit both externally and internally between said enlargements, said Venturi-like portions being in unobstructed communication with said cylindrical portions, each of said Venturi-like portions having a restricted substantially annular (either continuous or a ring of perforations) auxiliary port from the interior to the exterior of its contracted intermediate portion, and tubular means surrounding at least parts of said Venturi-like conduit portions and spaced radially therefrom to provide annular pockets, the peripheral walls of said pockets having openings. Mufflers so constructed, well attain the ends for which they are designed and lend themselves admirably to use either with or without an enveloping jacket sleeve or the like.

It may be added that the pressure head at the peaks of the exhaust waves, is amply sufficient to overcome any vacuum that might otherwise exist at the Venturi throats. The wave phenomenon is due to the inertia of the gases and cannot be smoothed out before the gases enter the muffler except with a very long exhaust pipe or exorbitantly large manifold. A pressure gauge in the exhaust line (due to lag) fails to show the true state of affairs. The best it will show is the mean pressure. The peaks of the waves possess comparatively high pressure.

While various forms of construction have been shown for illustrative purposes, variations may of course be made within the scope of the invention as claimed.

I claim:—

1. In a muffler, an assemblage comprising a gas conduit having a plurality of axially alined Venturi-like formations providing alternate swells and restrictions, and ports from said restrictions to the exterior of the conduit, and means co-acting with at least portions of said restrictions in providing pockets at the exterior of said restrictions, said means having openings from said pockets to its exterior; a sleeve into one end of which said assemblage extends, said sleeve being spaced from the periphery of said assemblage and extending longitudinally beyond the same; and a second gas conduit snugly secured in the portion of said sleeve beyond said assemblage and composed of a plurality of axially alined Venturi-like formations providing additional alternate swells and restrictions, the restricted portions of said second conduit co-acting with said sleeve in forming pockets and having ports into said pockets, said sleeve having openings from said pockets to its exterior.

2. A muffler comprising a tapered gas conduit having a plurality of axially alined Venturi-like formations providing it with alternate swells and restrictions, said formations having ports from the interiors to the exteriors of said restrictions, a tapered sleeve in which said conduit is snugly fitted and secured, said sleeve co-acting with the exteriors of said restrictions in providing annular pockets and having additional openings from said pockets to the exterior of the sleeve, said sleeve having a gas inlet at its larger end and a gas outlet at its smaller end; a second tapered sleeve into whose larger end the first mentioned sleeve extends, said second tapered sleeve being tapered

in the same direction as said first mentioned sleeve, extending beyond the latter and being spaced from the periphery thereof; and a second tapered gas conduit having a second plurality of axially alined Venturi-like formations providing additional alternate swells and restrictions, said second conduit being snugly fitted and secured in the portion of said second sleeve between the first mentioned conduit and the smaller end of said second sleeve; said portion of said second sleeve co-acting with the exteriors of said additional contractions in providing additional pockets and having openings from said additional pockets to the exterior of said second sleeve, said second sleeve being provided at its smaller end with a gas outlet.

3. A muffler comprising a gas conduit composed of a plurality of axially alined tubular portions, each of which is provided with a swelled intermediate portion and contracted ends, said tubular portions being disposed in end-to-end relation and having their ends spaced apart to provide ports, and a sleeve in which said tubular portions are snugly fitted and secured, said sleeve co-acting with the exteriors of said contracted ends in forming pockets and having openings from said pockets to the exterior of the sleeve.

4. A muffler comprising a gas conduit having a plurality of axially alined Venturi-like formations providing it with alternate swells and restrictions, said restrictions having ports from their interiors to their exteriors; a sleeve in which said conduit is snugly fitted and secured, said sleeve co-acting with the exteriors of said restrictions in providing pockets and having openings from said pockets to its exterior; an outer imperforate jacket sleeve surrounding and spaced from the first mentioned sleeve and having closed ends, and annular gas baffles projecting from said first mentioned sleeve toward said jacket sleeve but spaced from the latter.

5. A muffler comprising a conduit composed of a plurality of short axially alined tubes disposed end to end, each of said tubes having cylindrical end portions, a perforated portion at the inner extremity of one of said cylindrical end portions, and a restricted portion extending from said perforated portion to the other of said cylindrical end portions; and additional short tubes snugly fitted and secured in the adjacent cylindrical end portions of the first mentioned short tubes, said additional short tubes having contracted ends extending within said perforated portions into said restrictions, said contracted ends being spaced inwardly from said perforated portions and restrictions, providing annular pockets with which the perforations communicate, and ports from the interior of the conduit into said pockets.

6. In a muffler, an assemblage comprising a conduit having a plurality of axially alined Venturi-like formations providing alternate swells and restrictions, and ports from the interiors to the exteriors of said restrictions; and means at the exterior of the conduit co-acting at least with portions of said restrictions in forming pockets with which said ports communicate, said means having additional openings from said pockets to the exterior of the latter; said conduit having a gas inlet at one end and a gas outlet at its other end; and a jacket sleeve surrounding the above-defined assemblage, said jacket sleeve having a dome-like front end provided with air admission openings, being tapered rearwardly and having longitudinally spaced air and gas discharge openings.

7. A muffler comprising an elongated cylindrical casing having longitudinally spaced groups of perforations, short cylindrical tube members secured in and in contact with said casing, said short cylindrical tube members being located between said groups of perforations, and Venturi-like tubes extending between said short cylindrical tube members, each of said Venutri-like tubes having both of its ends enlarged and disposed directly at and in gas-tight relation with the adjacent ends of the two adjacent cylindrical tube members, said Venturi-like tubes having passages from the interiors to the exteriors of their contracted intermediate portions, the perforations of said cylindrical casing being in portions thereof which do not contact with said Venturi-like tubes.

8. A muffler comprising longitudinally spaced axially alined cylindrical conduit portions and Venturi-like conduit portions between and axially alined with said cylindrical conduit portions, said Venturi-like conduit portions having enlarged ends in unobstructed communication with said cylindrical conduit portions, being contracted both internally and externally between their ends and being provided in their contracted portions with openings, and tubular means surrounding at least parts of said Venturi-like conduit portions and spaced radially therefrom to provide annular pockets, said pockets being placed in communication with the interiors of said Venturi-like conduit portions by means of said openings, the peripheral walls of said pockets having openings.

LAURENCE R. HEATH.