United States Patent [19]

Mucka

[11] **3,880,252**

[45] **Apr. 29, 1975**

[54] **MUFFLER**

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[73] Assignees: **H. K. Porter Company, Inc.**, Pittsburgh, Pa.

[22] Filed: **July 1, 1974**

[21] Appl. No.: **484,587**

Related U.S. Application Data

[62] Division of Ser. Nos. 365,956, June 1, 1973, and Ser. No. 478,709, June 13, 1974.

[52] **U.S. Cl.** ..... **181/60;** 181/46; 181/35 C; 181/36 B

[51] **Int. Cl.** **F01n 1/10**

[58] **Field of Search** .... 181/35 R, 35 C, 36 R, 36 A, 181/36 B, 47 R, 47 A, 47 B, 49, 56, 60, 65, 64 R, 64 A, 64 B, 68

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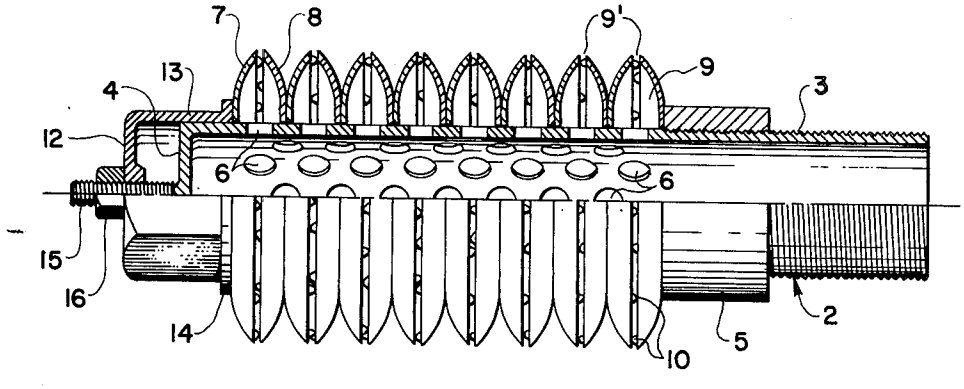
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[57] **ABSTRACT**

An exhaust muffler for internal combustion engines and compressed air tools or other air-operated machinery has a tubular core normally closed at one end, with a connecting portion at its other end for connecting the core to a source of exhaust gases to be discharged. Intermediate its two ends the length of the core is perforated lengthwise and peripherally, providing numerous parts through which the exhaust gases are discharged radially. A succession of dished or concavo-convex annuli are fitted about the perforated area of the core with alternate annuli reversed so that they are formed into pairs with the concave surfaces of the annuli confronting each other, the spaces between the several pairs of annuli providing attenuation chambers into which the gases flowing out of the core are discharged. The confronting edges of one or both annuli have projections thereon so arranged that there is a substantially continuous outlet space for gases around the periphery of each chamber. The series of annuli are confined between abutments at opposite ends of the tube which jam them against each other while the projections prevent the converging edges from making full edge-to-edge contact.

4 Claims, 4 Drawing Figures



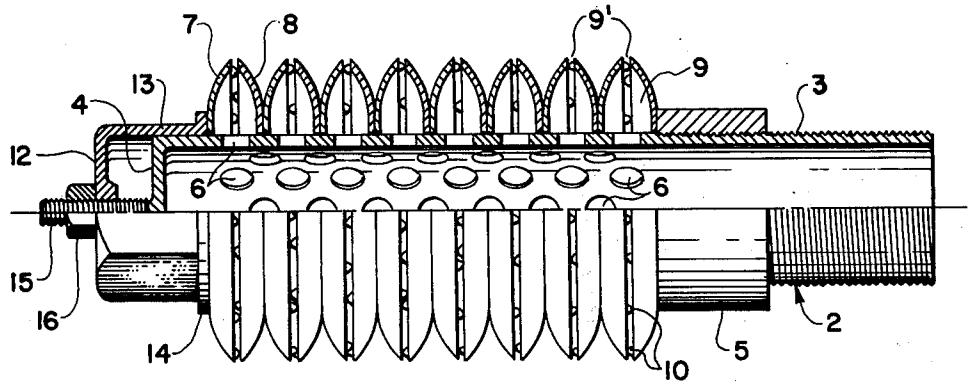


Fig. 1

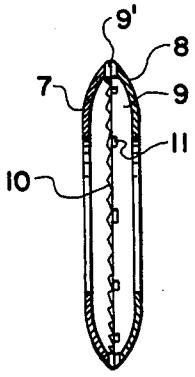


Fig. 2

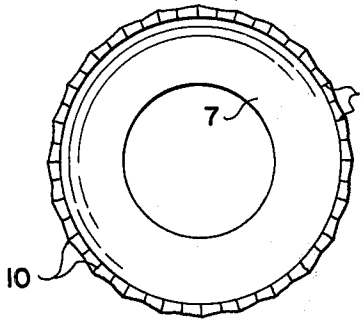


Fig. 3

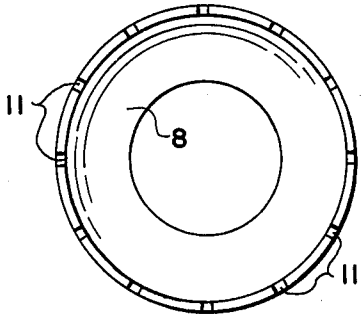


Fig. 4

MUFFLER

This application is a division of my application Ser. No. 365,956, filed June 1, 1973 and of continuation-in-part application Ser. No. 487,909, filed June 13, 1974, which continuation application, so far as it is relevant, is incorporated herein by reference, and is for a muffler for internal combustion engines, compressed air tolls and elsewhere where the noise of escaping gases into the atmosphere is to be muffled or reduced, and back pressure in the exhaust system to which the muffler is applied, minimized.

With the increased use of internal combustion engines and compressed air tools and machinery, much study has been given to the development of a muffler which would reduce exhaust noise to a more acceptable level. The injurious effects of "noise pollution" and the need to protect workmen from exhaust noise is recognized as a health problem. The present invention is designed to provide a relatively inexpensive muffler of a unique construction, less susceptible to corrosion, but which in tests in both government and private laboratories has been proved to be exceptionally effective.

The present invention provides a muffler of compact construction which has proved to be equally or more effective in cases where it has been tested than a favored conventional type muffler presently in wide use, but it is relatively more compact, self-cleaning and incapable of retaining condensate or corrosive exhaust products. It is designed to produce minimum back pressure in the exhaust system of the air or combustion engine with which it is used. Because of its compact construction it is especially well adapted to use on portable compressed air and internal combustion engine-driven tools, including air-driven percussion tools, power lawn mowers, chain saws, etc., where present mufflers are quite ineffective, but it can also be advantageously and effectively used on automobiles, tractors, stationary air-operated machinery and elsewhere, particularly where under normal conditions the engine operates at a fairly uniform speed so that under normal conditions the exhaust gas volume is fairly constant.

The muffler of this invention comprises a tubular core having one end threaded or otherwise formed for connection into an exhaust port of an engine, or applied to an exhaust pipe, or attached to some other source of exhaust gases to be muffled. A portion of the length of the core intermediate its ends has numerous closely-spaced openings therethrough around the entire periphery of the core. Around one end of the core there is provided an annular abutment. The other end of the core is preferably completely closed. Around the outside of the perforate area of the core are slidably fitted a plurality of dished washer-like concavo-convex annuli alternatively reversed so as to be arranged in pairs where the concave surfaces of each pair are in confronting relation and their peripheral edges converge toward each other, an attenuation chamber being thereby provided between the annuli of each pair. Exhaust gases entering the core will flow through the numerous openings in the core into the attenuation chambers and escape from around the periphery of each chamber through a narrow annular gap between the converging edges of the confronting annuli. The series of annuli so provided are confined at one end by said fixed abutment, and at the other end by a second abutment which may in some cases be adjusted toward or away from the first. According to this invention, they are ordinarily pressed so tightly against one another that they are relatively immovable, but they are so formed with multiple projections on the edges of one or both annuli of each pair as to provide for escape of gases from the chamber around their peripheries. The assembled unit has an "accordion pleated" appearance with annular corrugations by the succession of annuli so arranged, providing in addition an effective heat-dissipating surface.

I am aware that it has heretofore been proposed, as disclosed in British Pat. No. 10,297 of 1910 to Karthaus to provide a device for diffusing the exhaust gases from an engine into the atmosphere in such finely-divided thin streams as to render them invisible, and for this purpose there is provided a unit having two parallel pipes with a connector at one end into which the exhaust pipe of an engine discharges gases, and a connector at the other end through which the two pipes also communicate. Each pipe is perforated intermediate its ends around and along the greater portion of its length, and slidable on the pipes are a plurality of plate-like members which are so arranged that each two plates form a hollow body. The exhaust gases pass through the perforations in the pipe and enter the hollow bodies. A tension spring located between the two pipes is connected at each end to a follower that is slidable along both pipes so that the spring simultaneously exerts a yielding pressure against both ends of the series of plates on each pipe to hold all of the plates in each series tightly pressed against one another, so that the gases, entering the hollow bodies, escape under pressure. The escaping gases must be in such fine streams that they are said to become quickly invisible. In other words, the pressure builds up in the chambers between the pairs of disks to a point where the gases are forced out between contacting edges of the disks at high velocity. Just as with any other nozzle, the gain in velocity must be secured at the expense of a decrease in flow and thereby build up a back pressure in the exhaust system. A build-up of pressure capable of achieving the result sought by this patentee must be substantial. This necessarily reduces the efficiency of the engine, and must also result in an increase in noise. Both results defeat the purpose of a muffler, which should eliminate back pressure as much as possible and discharge the exhaust gas as quietly as possible. While the devices of this patent may have a superficial resemblance to the invention herein disclosed, it is in fact not a muffler nor would it or any similar device be a desirable accessory in the exhaust system of an engine or air motor.

The invention may be more fully understood by reference to the accompanying drawings showing a present preferred embodiment of one form of the invention.

FIG. 1 is a side elevation of the complete muffler with the upper half in section;

FIG. 2 is a vertical section through a single pair of annuli removed from the core;

FIG. 3 is a face view of one of the two disks shown in FIGS. 1 and 2; and

FIG. 4 is a face view of the other of the two disks shown in FIG. 2.

Referring to the drawings, 2 designates generally a core member comprising a straight tubular metal body having one end 3 externally threaded or otherwise

formed for connection with a source of gas to be muffled or diffused and having its opposite end closed or plugged as indicated at **4.** The threaded end of the body has a sleeve **5** thereabout forming an annular shoulder or abutment. The major portion of the area of the core intermediate the abutment **5** and the opposite is of uniform diameter and end has numerous closely-spaced small openings **6** therethrough which may be round holes, slits or other small openings. Fitted over the outside of the core with a sliding fit are a succession of disks or annuli **7** and **8** of generally similar construction, each being dished or concavo-convex, and every other one is reversed with respect to the adjacent ones so as to form confronting pairs of such annuli, the central outside areas of the annuli, as distinguished from their inner concave surfaces, have full back-to-back contact designed to prevent any wobble or canting of the annuli on the tube. The peripheral edges of the annuli of a pair converge toward a common plane at right angles to the axis of the tubular core. The annuli of each pair provides between them an annular chamber **9** around the core into which gases from the interior of the core escape from the core through the perforations **6.** These chambers constitute attenuation chambers which are in section from the core outward which generally resembles a half of an ellipse and are of decreasing section toward their peripheries. These teeth contact the edge of the opposing annulus **8,** these projections preventing the annuli from being forced into full edge-to-edge contact and assure that there will be an effective annular gas escape passage or gap **9'** around the periphery of each chamber **9.** This passage is designated **9'** in the drawings. The other annuli **8** may have an entirely smooth edge for contact with the projections **10** of the annuli **7,** or **8** may be similar to **7** with the projections widely separated and the annuli of one being staggered with respect to those of the other as shown in FIG. **1,** or as shown in FIGS. **2** and **4,** the annuli **8** may have notches **11** formed therein at more or less frequent intervals around the edges providing additional gas escape opening that may be desirable in giving some lateral irregularity to any otherwise laminar discharge of gases from the periphery of the chamber, or which may even be made after the muffler has been tested to slightly enlarge the gas escape passage from the chambers while keeping the annuli tightly jammed together between the two abutments as hereinafter more fully described.

The annuli are preferably stamped from heat and rust-resistant ferrous metal alloy. The series of annuli so arranged are confined against the abutment **5** at one end of the perforated area and by another abutment member at the other end which may also be adjustable. This member is here shown as a cap-like member **12** with a skirt **13** fitting over the core and having a lip **14** that bears against the endmost disk or annulus at the other end of the perforated area of the core. The exterior of the skirt **13** may be formed with flattened surfaces thereon to which a wrench may be applied. The end of this cap has a central perforation fitted over or screwed onto a threaded stud **15** projecting from the closed end of the core. A retaining nut **16** is on this stud. By adjusting the cap with respect to the succession of disks the distance between the abutment **5** and cap **12** can be adjusted, this arrangement providing in effect a micrometer adjustment and thus control the total clearance or widths of the gaps **9'** between the several pairs of annuli in cases where some looseness between the annuli is not objectionable. Normally, however, the annuli are jammed together to reduce wear on the contacting edges which may occur where there is relative motion between annuli. Jamming the annuli tightly together also assures that the opposed edges of the annuli will be parallel, to secure uniformity.

As shown in the drawings the round holes have a diameter less than the greatest distance between confronting concave faces of the annuli of each pair, that is the distance between the annuli of each pair where they fit around the tube, and the center-to-center distance between holes which are in a line parallel with the axis of the tubular core is equal to the diameter of the holes but alternate holes around the periphery are staggered. The result of this is that the annuli in forming the attenuation chambers are so positioned that they straddle at least one ring of holes and in all cases one annular ring of openings will be centered on the plane of the peripheral opening around each attenuation chamber. Also, except in the two endmost chambers, at each side of the full ring of openings the adjacent rings or openings, straddled as they are by adjacent annuli will open partly into one side of one attenuation chamber and partly into the other side of the adjacent attenuation chamber, providing what may be termed primary openings in the central plane of each chamber and an annular series of secondary openings at each side of the primary series. In the end chambers as here shown there is one row of primary openings and one row of secondary openings, so that these chambers receive a lesser amount of exhaust gas but have the same peripheral opening as the other chambers. Also, as hereinafter pointed out, it is possible to omit one or more chambers, in which case any such partial differences between the end chambers and the intermediate ones is eliminated. In any caase there are openings into each chamber at intervals around the tube and also along the length of the tube and in all cases there is one full annular ring of openings in the mid plane of each chamber with an annular row of openings of lesser area on at least one side of said mid-plane, and, except perhaps the end ones, on both sides of said mid-plane.

As herein shown and described, the muffler provides a uniform series of attenuation chambers between concavo-convex annuli arranged in pairs with the concave surfaces of the two annuli of each pair confronting one another and with a gas escape passage around the periphery of each chamber. Gases passing into these chambers through the perforations in the core lose velocity as they flow radially outward in all directions away from the tube and leave the periphery of the chamber at low velocity. Because of the large diameter of the annuli relatively to the tubular core, a small gap around the periphery of the chamber provides a relatively long gas escape port. For example with disks 1 ½ inches in diameter, the slot around the periphery is slightly more than 4.5 inches, and if there are even as few as four pairs of annuli the combined length of the chamber outlets is close to one and one-half feet. Consequently any change in the length of the projections **10,** or their contour or spacing, or in the location and size of the notches **11** when the annuli are jammed together can increase or decrease the peripheral outlet area from the chambers **9,** and if there may be some looseness between the annuli which will allow in-

creased separation of as little as 0.005 of an inch, the total increase in "port area" will be considerable. In any case, as with other mufflers, empirical formula cannot be established for all engines and machinery, but in general it is desirable that the gases escape freely from the peripheries of the chambers with minimum back pressure while the enclosures **9** confine noise or noise-producing vibrations. Knowing the volume of gases and the rate of flow, one has little difficulty in co-relating the diameter of the tube, the minimum of perforations and the diameter and edge spacing of the annuli or the number of pairs of annuli. In other words, the area of the peripheral opening on each chamber should be no less than the combined areas of the openings leading from the interior of the tube into each chamber but should not exceed a maximum width to provide effective sound attenuation. For increased volume of gases the tubular core may be of larger diameter and the diameter of the annuli may be increased, or the number of chambers may be increased, all without increasing the width of the peripheral opening beyond effective limits. By having both abutments **5** and **13** adjustably fixed by thread connection with the body, the entire series of annuli may be shifted lengthwise along the perforate area of the tubular body to locate them most favorably over the perforations in the tubular body, and with a cap-like abutment **13** it may be possible to omit one or even more chambers, depending on the length of the capa and the screw **15.**

I claim:

1. A muffler for suppressing the exhaust noises of internal combustion engines and air-driven machinery comprising:

a. a straight tubular body having means at one end for connecting it to the exhaust of an internal combustion or air-driven motor and having a closure at its other end, a length of the tubular body intermediate its ends being of uniform diameter and having perforations therein extending lengthwise and circumferentially of the body,

b. a series of dished annuli on the tubular body over said perforated length of the tubular body, each annulus being of concavo-convex shape with a central opening through which the tube is slidably passed, said annuli being arranged in several pairs in which the concave surfaces of the annuli of each pair are in confronting relation and the peripheral edges of the concave surfaces of the two annuli converge toward a common plane and the central areas of the outer surfaces of the annuli are in back-to-back contact, each such pair providing an attenuation chamber with opposing concave walls around the tubular body extending from the exterior of the tubular body to the periphery of the pair of annuli, said attenuation chambers and the openings in the tubular body being so disposed as to introduce gases from the tubular body into each attenuation chamber both at its mid plane and on at least one side of said mid plane,

c. at least one annulus of each pair having a plurality of projections about its edge which contact the confronting edge of the other annulus of the pair to prevent full edge-to-edge contact between the two annuli of the pair to assure clearance space for the discharge of gases from around the periphery of the chamber formed between said annuli of each pair, all of the annuli being jammed tightly together by tightening them between two abutments secured to the tubular body, the clearance space so provided opening directly into the atmosphere.

2. A muffler comprising a straight tube of uniform inside diameter having means at one end for connecting it with a source of exhaust gas to be muffled and closure means at the opposite end, a succession of concavo-convex annuli fitted on and supported by the tube in contacting back-to-back relation, each annulus being reversed with respect to the adjacent ones to form pairs having confronting concave surfaces with the peripheral edge portions of confronting annuli converging, each pair of annuli forming an annular chamber between them extending from the exterior of the tube to the converging edges thereof, means for holding said converging edges of each such pair spaced from each other to form an opening substantially around the periphery of each chamber between the confronting edges, said tube having openings around its periphery and along its length arranged to discharge exhaust gases from the tube into each chamber in a plurality of transverse planes with one complete annular ring of such openings being centered on the mid-plane between the two confronting annuli of each pair, the area of the peripheral opening around each pair of annuli being no less than the combined areas of the openings leading from the tube into each chamber whereby gases flowing from the tube into each chamber may escape freely around the periphery to the atmosphere, said opening around the periphery of each chamber discharging directly to the atmosphere, and means for fixing the annuli in predetermined position relative to one another on the tube and restraining them against longitudinal or relative rotating motion during the operation of the muffler.

3. A muffler as defined in claim **2** in which said last-named means comprises an abutment on the tubular body at each end of said succession of annuli for confining them over the length of the tubular core in which the annular openings are formed, at least one such abutment being threaded on the tubular body for adjustment toward and away from the other.

4. A muffler as defined in claim **3** in which both of said abutments are threaded onto the tubular body whereby the entire succession of annuli may be adjusted lengthwise of the perforated length of the tube while holding them in operation tightly jammed together.

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