United States Patent [19]

Gibel

[11] **3,842,932**

[45] **Oct. 22, 1974**

[54] **SOUND-TRAP MUFFLER**

[76] Inventor: **Stephen J. Gibel,** 5846 Edgerton Rd., North Royalton, Ohio 44133

[22] Filed: **Nov. 1, 1972**

[21] Appl. No.: **302,758**

[52] **U.S. Cl.** **181/50,** 181/49, 181/42, 181/55, 181/69

[51] **Int. Cl.** **F01n 1/10,** F01n 1/24

[58] **Field of Search** .... 181/35 R, 36 R, 36 C, 47 R, 181/40, 46, 42, 49, 50, 55, 57, 63, 68, 69, 71, 72, 47 B, 36 B

[56] **References Cited**

UNITED STATES PATENTS

1,067,467	7/1913	Collins	181/69
1,067,468	7/1917	Collins	181/69

FOREIGN PATENTS OR APPLICATIONS

1,295,934	5/1969	Germany	181/47 A
454,537	6/1968	Switzerland	181/53
270,541	5/1927	Great Britain	181/69

Primary Examiner—Richard B. Wilkinson
Assistant Examiner—Vit W. Miska
Attorney, Agent, or Firm—Ely & Golrick

[57] **ABSTRACT**

Muffler for sound transmitted by low-volume exhausts comprising a structure providing a plurality of aligned cylindrical chambers having acoustic surfaces of alternate large and smaller diameters, and concentric dividers substantially centered in the larger chambers, whereby the area between the periphery of each divider and the adjacent walls of a larger chamber is at least equal to the area of the otherwise open bore through the aligned chambers. Restriction of flow of gas through the muffler is minimized and the diameter of the divider is at least equal to the diameter of the bore, whereby the mean free path for sound waves through the aligned chambers is equal to at least substantially twice the length of the bore to thereby trap and adsorb sound waves transmitted by the air in the aligned chambers.

5 Claims, 3 Drawing Figures

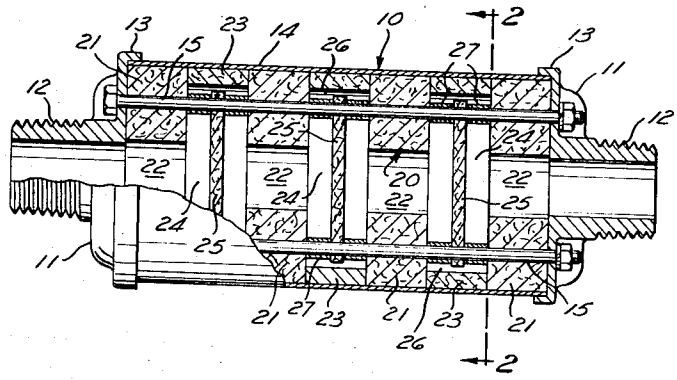


Fig. 1

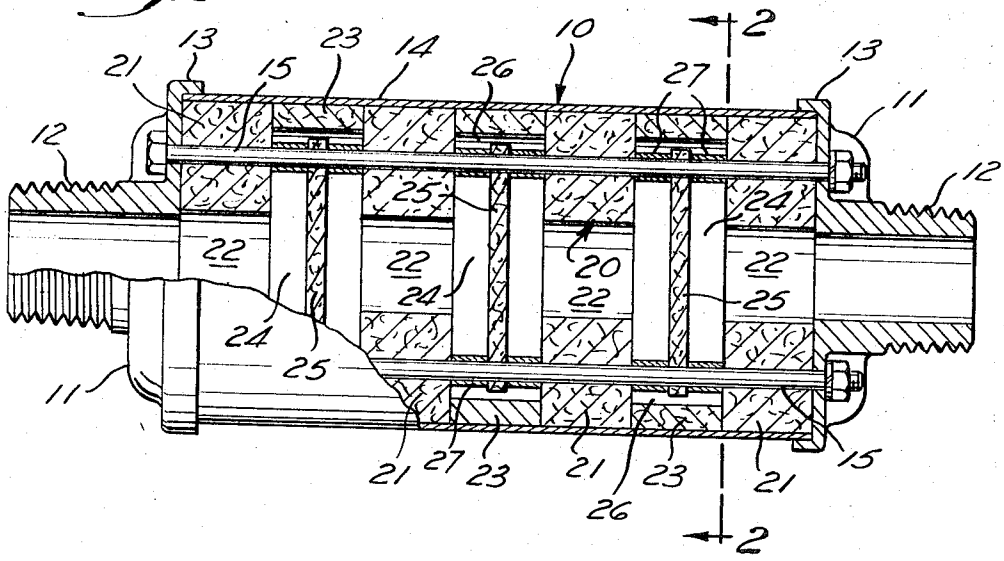
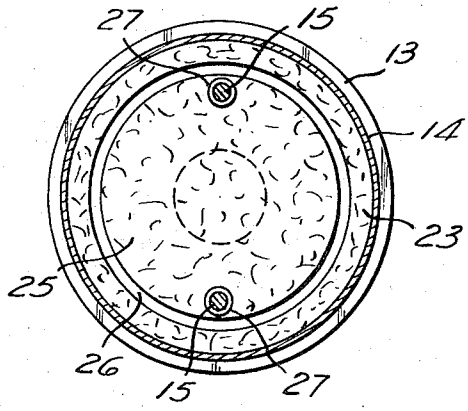


Fig. 2



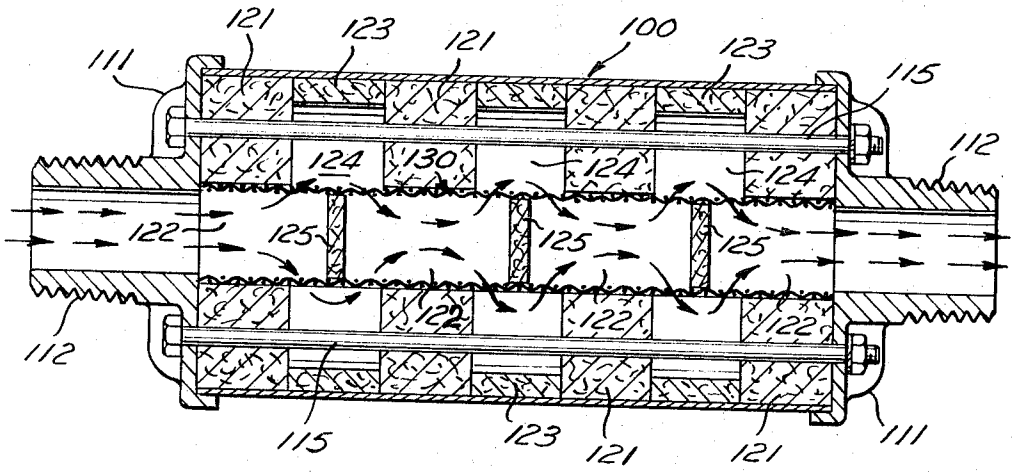


Fig. 3

SOUND-TRAP MUFFLER

This invention relates to mufflers for silencing sound conveyed by the exhausts of air and like gases and vapors, and particularly low volume and/or low velocity air exhausts, as from the exhausts of vacuum pumps.

The advancing state of the art for silencing pneumatic and like gaseous and vaporous exhausts introduced into the mufflers at relatively high velocities and super-atmospheric pressures has achieved mufflers of increasing compactness and/or efficiency, as exemplified, for example, by my prior U.S. Pats. Nos. 2,600,236 (issued June 10, 1951); 2,815,088 (issued Dec. 9, 1957); 3,380,553 (issued Apr. 30, 1968) and my subsequent issued and pending applications. These and competitive mufflers largely depend for the attenuation of the sound energy in the above exhausts by (a) a dissipation of the sound energy through expansion and/or turbulence within the muffler and (b) dissipation and dissemination of the exhaust to the atmosphere through porous walls of acoustic material in an expansion chamber due to a pressure differential between the ambient atmosphere and the expanded exhaust within the ultimate expansion chamber of the muffler.

The above-described mufflers, or others depending merely upon the internal baffling of high velocity air and gases introduced into them, have been signally unsuccessful, however, in silencing the sound energy transmitted by low-volume and low-velocity exhausts of, for example, vacuum pumps. The noise of such latter exhausts, often of low frequencies (in the order of 50 to 150 Hertz), can be very annoying and distracting and may constitute occupational safety and health hazards. Because of the low volume of air or gas discharged through such devices, particularly as they approach the very low vacuums now in wide commercial use or as they maintain a low sub-atmospheric pressure in suction devices, the volume and velocity of such exhausts neither permit the attenuation of their sound energy (created by the operating mechanisms within the vacuum pumps) nor, because the static pressure within the muffler is practically atmospheric, is there a pressure differential to force air by which the sound is conveyed through the porous walls of acoustic material. Heretofore, the only solution to meeting the regulatory standards for silencing such exhausts has been to provide mufflers having an exceptionally large internal volume (especially with respect to the low volume of exhausted air) whereby the sound energy in the essentially static air within the muffler is absorbed and dissipated by the mass of material from which the muffler is made. The very bulk of such mufflers not only increases the cost of them but renders them impractical or unacceptable where the muffler has to be located in close quarters.

It is an object and advantage of this invention to provide a compact and highly efficient muffler for such low-velocity exhausts. It is of a relatively simple and easily assembled construction and, thus, of substantially lower cost than any muffler of comparative effectiveness. Although mufflers made according to this invention employ conventional sound-absorbing acoustic materials, the relatively low mass of such material required and the consequent relatively low internal and external volume of the mufflers indicate that the effectiveness of mufflers made according to this invention is not solely due to absorption of the sound energy of the

acoustic material, as in prior art large volume mufflers, of comparable effectiveness for such exhausts. Rather, analysis of the sound waves in the internal chambers and at the outlet of these mufflers suggests that the mufflers' construction creates out-of-phase sound waves within their essentially static internal volumes of air, lopping off the crests of the sound waves and altering their laminar flow paths, although further and more exhaustive studies and analyses may develop other explanations for the operativeness of mufflers made according to this invention.

Mufflers made according to this invention are also highly effective in silencing the sound of the frequently comparatively large volume of exhausted air and/or other gases, which may have to be handled as vacuum pumps commence to evacuate a closed chamber. These mufflers also provide very low to practically zero back-pressure, likewise a pre-requisite for efficient operation of vacuum pumps and the like.

Other objects and advantages of this invention will be apparent from the following specification, claims, and drawings, in which:

FIG. **1** is a side elevation, partly in section to show the internal construction of a preferred embodiment of mufflers made according to this invention.

FIG. **2** is a cross-section taken along the line **2—2** of FIG. **1.**

FIG. **3** is a side elevation, partly in section, showing another embodiment of this invention.

Referring to the preferred embodiment shown in FIG. **1,** the muffler **10** is comprised of a pair of end caps **11,** each provided with a pipe-threaded central tubular boss **12,** permitting either end to be connected to the exhaust port or line of a vacuum pump, for example. Each end cap is provided with a flange **13** providing an internal shoulder to receive the ends of an external tubular cylindrical wall **14** held under compression by the pair of internal tie bolts **15** extending between the end caps **11.**

The external wall **14** is preferably of relatively light-gauge sheet metal sufficient to carry the load of the tie bolts **15** and to protect and support the internal rings of acoustic material **20** defining the sound traps of the muffler. Because such external walls in cylindrical mufflers silencing high-volume exhausts are generally perforate to permit the dissemination of exhaust air therethrough, the wall **14** may likewise be perforated to indicate that the muffler **10** is, in fact, a muffler, but preferably the wall **14** is imperforate, both to reduce cost and protect the acoustic material from absorption of oil and other liquids or soil which may contact the muffler during handling and use so as to become absorbed in the acoustic material **20** and, thereby, reduce its effectiveness.

The internal acoustic material **20** in the muffler **10** comprises a stack of alternate rings **21** and **23** having an outer diameter substantially equal to the internal diameter of the wall **14.** The rings **21** have an inner diameter substantially equal to or slightly greater than the bore of the bosses **12** and an axial thickness substantially equal to their inner diameter, whereby the chamber **22** provided by each ring **21** is substantially "square" (i.e., its axial length is substantially equal to its diameter). Each alternate ring **23** is of an axial length substantially equal to that of a ring **21,** but its internal diameter, providing a chamber **24,** is appreciably larger, in the order of 2.5 to 3+ times the diameter of

the bore of the bosses **12.** As shown in FIG. **1,** the internal construction of the muffler **10** comprises a plurality (seven) of alternate large and small volume chambers in which the volume of each large chamber is in the order of six to ten times the volume of the smaller chamber.

Each larger chamber **24** is partitioned centrally by a partition **25** having a diameter substantially larger than the bore of the adjacent smaller chamber **22** but sufficiently less than the internal diameter of the chamber **24** so as to provide an annular passageway **26** within the chamber **24.** The area of the passageway **26** is at least equal to the cross-sectional area of the bore of the bosses **12** and thereby minimizes restriction of flow of air through the muffler **10.** The rings **21** and partitions **25** are pierced to permit the stacking of them on the tie bolts **15.** To maintain the central spacing of the partitions **25** in the chambers **24,** small tubular sleeves **27** may be carried on the tie bolts **15** on each side of a partition **25.**

The acoustic material of the rings **21** and **23** and partitions **25** is preferably made of fiber loosely felted to provide a material of low-density and anechoic properties; for structural stability the fibers may be lightly resin-bonded. It has been found that the acoustic material of the rings **23** and partitions **25** may be denser, providing structural stability for diverting the path of the sound waves through the muffler without noticeably decreasing its effectiveness.

For reasons not yet understood the effectiveness of the muffler drops sharply if the stack of alternate chambers provides less than two larger chambers **24** and three smaller chambers **22;** the effectiveness is appreciably increased with the arrangement providing three larger chambers **24,** as shown in FIG. **1.** Additional pairs of alternate large and small chambers may be added to the stack, but the increase in effectiveness of the muffler becomes asymptotic.

The modification **100** shown in FIG. **3** is similar to that shown in FIG. **1,** comprising end caps **111,** with bosses **112** and connected by tie rods **115** to support an outer wall **114.** Internally, alternate rings of acoustic material **121** and **123,** corresponding to rings **21** and **23,** are stacked to provide alternate chambers **122** and **124.** An internal perforate tube **130,** however, extends through these chambers, the internal diameter of the tube **130** constituting a connection of the bores of the bosses **112.** At the axial center of each chamber **124,** however, the tube **130** is blocked by a partition **125,** preferably of acoustic material similar to that employed for the partitions **25.** The perforated material of the central tube **130** may be perforated metal or screening whose open area is in the order of 50% of its total area whereby no substantial resistance is effected with respect to the low volume of air which flows through the muffler but the mean free path for sound waves in the muffler is in the order of twice the axial length of the tubes **130.**

Other modifications and variations of this specific embodiment of this invention as disclosed herein may be made by those skilled in the art without departing from the spirit and scope of this invention as defined in the appended claims.

What is claimed is:

1. A muffler for a low-volume exhaust comprising a casing having end closures therefor, each closure having an opening into the interior of said casing and at least one such opening permitting connection to an exhaust outlet, a plurality of adjacent axially concentric ring structures within said casing, said ring structures having alternate larger and smaller inner diameters, the axial thicknesses and inner diameters of said ring structures defining alternate large and small volume chambers, the cross-sectional areas of said chambers being aligned with said casing openings and the cross-sectional area of the smaller chambers being at least as large as the cross-sectional area of either of said casing openings to provide a bore through said muffler, and a partition located within each of the larger chambers and closing off said bore thereat and means to support said partitions so as to provide a passageway around each partition having a total cross-sectional area not less than the cross-sectional area of said bore but whereby the mean free path through said muffler is longer than the axial length of said bore through said chambers, said chambers having surface portions of substantially anechoic acoustic material whereby said chambers provide traps for sound waves therewithin.

2. A muffler as defined in claim **1** in which said chambers are formed by stacked rings of said acoustic material, the axial length of the rings defining the smaller chambers being substantially equal to the diameter of said bore, and at least a pair of rings defining said larger chambers and each having an axial length substantially equal to the axial length of the rings defining adjacent smaller chambers.

3. A muffler as defined in claim **2,** in which the volume of each of said larger chambers is at least six times the volume of one of said smaller chambers.

4. A muffler as defined in claim **3** in which said partitions are supported within said larger chambers and extend radially beyond the bore openings in said adjacent smaller chambers, the surfaces of each of said partitions being spaced from adjacent surfaces of the larger chamber in which it is supported to provide a passageway around it, each such passageway having a total cross-sectional area not less than the cross-sectional area of said bore.

5. A muffler as defined in claim **3** in which a perforate tube extending between the openings in said casing fits the bores of said smaller rings, partitions blocking said tube and located within the portions of said tube passing through said larger chambers, the perforations in said tube being substantially evenly distributed therein and providing opening areas on either side of each partition into an adjacent larger chamber, the total area of such opening areas on either side of each of said partitions being at least as large as the cross-sectional area of said tube.

* * * * *