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Wang

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[54] **POWER TUNED WAVE INTERFERENCE SILENCER**

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[52] **U.S. Cl.** ..... **181/44;** 181/36 E; 181/67

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

[58] **Field of Search** ..... 181/66, 67, 44, 46, 36 E; 60/312–316

[56] **References Cited**

UNITED STATES PATENTS

1,612,584	12/1926	Hunter et al.	181/67
2,359,365	10/1944	Katcher	181/67
2,911,055	11/1959	McDonald	181/67
3,700,069	10/1972	Rausch et al.	181/67 X

FOREIGN PATENTS OR APPLICATIONS

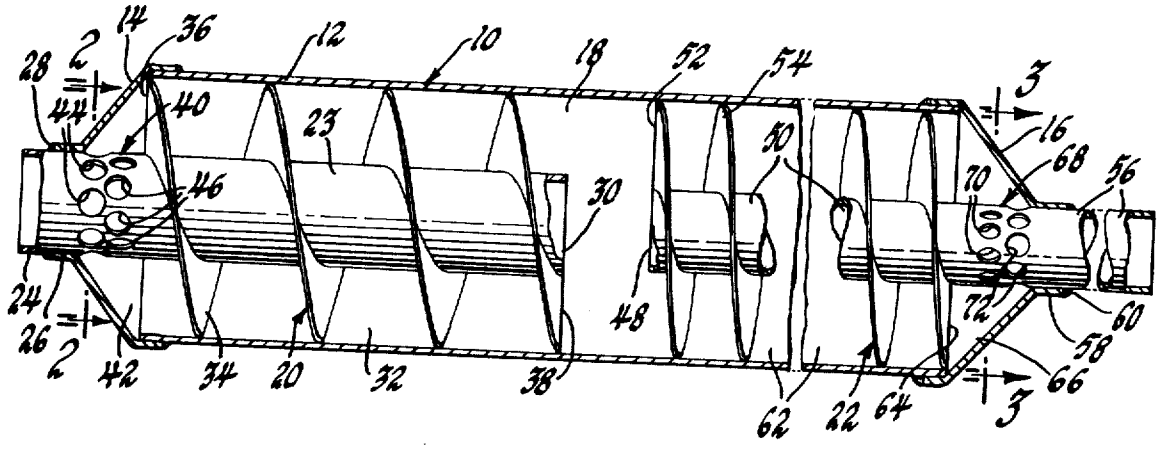
804,593	4/1936	France	181/67
292,323	6/1928	United Kingdom	181/67
677,875	6/1939	Germany	181/67

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Assistant Examiner—John F. Gonzales
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[57] **ABSTRACT**

A silencer assembly comprises a sealed housing having an inlet wave interference section and an outlet wave interference section with an open volume formed by the sealed housing therebetween. The wave interference sections are spaced within the sealed housing to produce interaction of sound wave energy for wave cancellation between each wave interference section. The first section serves as a power tuning device to reduce the overall size of the silencer having an appropriate length to produce a gas pressure pulse reflected back from the first interference section to the exhaust port of an engine for producing a negative pulse to reduce back pressure and improve exhaust port scavenging. The inlet interference section includes a set of holes therein joining one end of an outer flow path therein to the open volume with the outer path length being selected to broaded the negative pulse to achieve improved scavenging effect.

4 Claims, 4 Drawing Figures



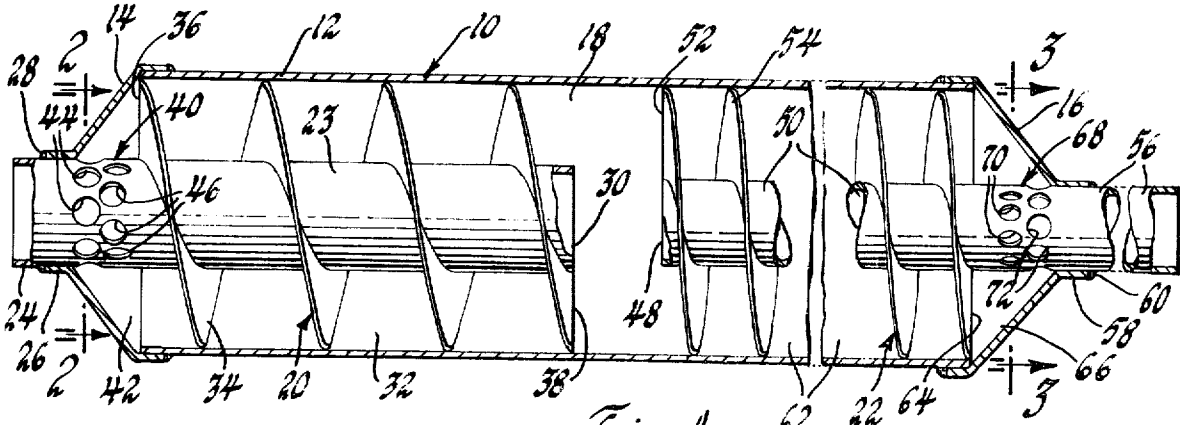


Fig. 1

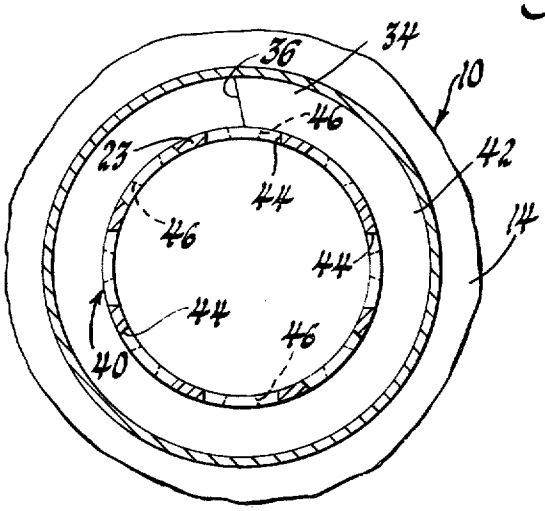


Fig. 2

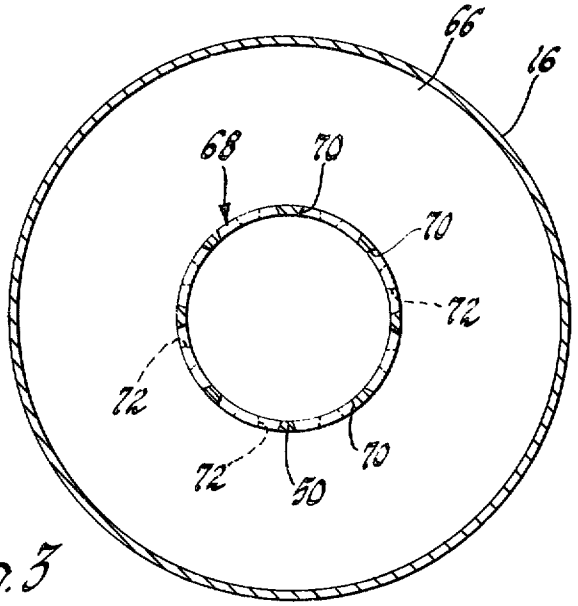


Fig. 3

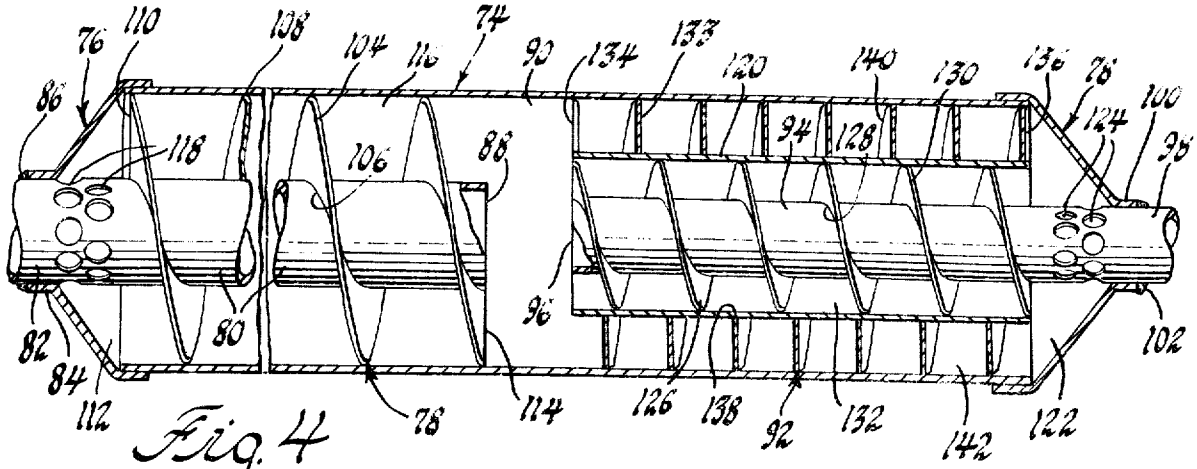


Fig. 4

POWER TUNED WAVE INTERFERENCE SILENCER

This invention relates to engine mufflers and more particularly to engine mufflers utilizing wave interference silencing techniques.

Certain vehicles are operated in a constant engine speed range, for example, snowmobiles, tractors and the like are operated in the range of 5500 to 6500 revolutions per minute. In such vehicles, it is desirable to include a silencing device that will produce good scavenging of exhaust ports in the vehicle engine within the constant operating speed range and which further, will produce attenuation of a broad range of sound frequencies in the engine exhaust. Furthermore, in such vehicles, it is desirable to maintain the silencer assembly as compact as practical while retaining the advantages of improved engine scavenging and sound attenuation.

An object of the present invention is to provide an improved silencer assembly including a sealed outer casing having wave interference sections at opposite ends thereof separated from one another by an open volume within the interior of the sealed outer casing and wherein one of the wave interference sections defines an inlet into the sealed outer casing and is tuned to produce a reflected wave pulse to the exhaust port of an engine for reducing back pressure and improving scavenging of exhaust gases from the engine and wherein both the first and second wave interference sections combine to attenuate a wide range of sound frequencies in the engine exhaust.

Still another object of the present invention is to provide an improved multiple function silencer assembly having lower cost and fewer pieces and including means for reducing back pressure at an engine exhaust port and producing less turbulent noise in the interaction regions of a pair of separated wave interference silencer sections within the assembly.

Yet another object of the present invention is to provide a compact, power tuned wave interference silencer including an inlet wave interference section and an outlet wave interference section having a sealed open volume therebetween; the first section serving as a power tuning device of reduced dimension that will produce a reflected gas pressure pulse from the outlet end of the inlet wave interference section to the exhaust port of an engine for scavenging the exhaust port and wherein an outer flow path of predetermined length is formed between a discontinuity defined by a set of holes and the open volume to broaden the negative pulse at the engine exhaust and wherein each of the first and second wave interference sections each attenuate a separate range of sound frequencies in the engine exhaust.

Further objects and advantages of the present invention will be apparent from the following description, reference being had to the accompanying drawings wherein a preferred embodiment of the present invention is clearly shown.

In the Drawings:

FIG. 1 is a longitudinal sectional view of a power tuned silencer assembly including the present invention;

FIG. 2 is an enlarged fragmentary sectional view taken along the line 2—2 of FIG. 1;

FIG. 3 is an enlarged fragmentary sectional view taken along the line 3—3 of FIG. 1; and

FIG. 4 is a longitudinal sectional view of a second embodiment of the present invention.

Referring now to FIG. 1, a power tuned wave interference silencer assembly **10** is illustrated including an outer casing **12** having an inlet end closure **14** on one end thereof and an outlet end closure **16** on the opposite end thereof. The outer casing **12** includes an intermediate open volume **18** that has a first wave interference device **20** at one end thereof and a second wave interference device **22** at the opposite end thereof.

More particularly, the wave interference device **20** includes a central open ended tube **23** therein including an inlet end **24** thereof supported centrally of the end closure **14** at a tubular extension **26** thereon. The inlet end **24** is sealed with respect to the annular extension flange **26** by means of a continuously formed circumferential weld **28** between the flange **26** and the outer periphery of the inlet end **24.** Inlet end **24** is connected to the exhaust pipe of an engine. The tube **23** further includes an outlet end **30** thereon located interiorly of the outer casing **12** at the open volume **18** therein.

The tube **23** has an outer diameter substantially less than the inner diameter of the outer casing **12** to form an annular outer flow path **32** therebetween. Within the outer flow path **32,** a helical wave interference baffle **34** is located having an inlet end **36** thereof located immediately downstream of the conically shaped enclosure **14** and an outlet end **38** formed at the outlet end **30** of the tube **23** at the open volume **18.**

The wave interference device **20** further includes a two-row set of holes **40** in the tube **23** formed immediately downstream of the tubular extension **26** to communicate the interior of the tube **23** with an annular volume **42** formed by the inner surface of the conically shaped enclosure **14** immediately upstream of the inlet end **36** of the helical baffle **34.** As best shown in FIGS. **1** and **2,** the set of holes **40** includes a first row of holes **44** and a second row of holes **46.** The holes **44** are eight in number and each have a 0.50 inch diameter. The holes **44** are equally circumferentially spaced from one another and are axially staggered with respect to the holes **46.** Likewise, the holes **46** are also eight in number; of 0.50 inch diameter; equally circumferentially spaced and alternately axially staggered with respect to the holes **44** in the first row. The total cross-sectional flow area of the set of holes **40** is approximately equal to the cross-sectional flow area of the tube **23** which in one working embodiment has a diameter of 1.875 inches. In one working embodiment, the baffle **34** has a height of 1.13 inches and a pitch of 2.29 inches and an internal diameter of 1.875 inches.

The outlet end **30** of the tube **23** and the outlet end **38** of the baffle **34** are spaced by the open volume **18** from the inlet end **48** of a second elongated tube **50** of the second wave interference section **22** and the inlet end **52** of a second helically formed wave interference baffle **54,** respectively. In this embodiment of the invention, the second tube **50** is arranged coaxially of the first tube **23** and includes an outlet end **56** directed exteriorly of the outer casing **12** centrally through an annular flanged extension **58** on the conically-shaped end closure **16.** The flanged extension **58** is sealed with respect to the outer surface of the outlet end **56** by means of a continuous circumferential weld **60.** Likewise, the tube **50** has a diameter reduced from that of the inner diameter of the outer casing **12** to form a second helical outer flow path **62** at the opposite end of the sealed in-

terior of the outer casing **12.** The baffle **54** is located within the outer flow path **62** and is helically formed between the inlet end **52** thereof to an outlet end **64** thereof located immediately upstream of an annular chamber **66** formed by the inner surface of the conical end closure **16.** The wave interference section **22** includes a set of openings **68** therein including a first row of openings **70** and a second row of openings **72** for communicating the interior of the tube **50** with the annular space **66.** In the embodiment of the invention illustrated in FIGS. **1** thru **3,** there are eight holes **70** equally circumferentially spaced from one another, each of 0.44 inch diameter. Each of the holes **72** are axially staggered with respect to the holes **70,** are eight in number and equally circumferentially spaced. Each of the holes **72** further have a 0.44 inch diameter. The baffle **54** has a height of 1.32 inches and an internal diameter of 1.5 inches which corresponds to the outer diameter of the tube **50.** The baffle **54** further includes a pitch of 1.23 inches along the length of the baffle **54.** The aforesaid arrangement produces a compact silencer assembly capable of attenuating a wide range of sound frequencies in an engine exhaust.

Furthermore, the tube **23** of the device **20** has a length that is tuned to produce a reverse pressure pulse in the exhaust system of a vehicle whereby a negative pressure pulse will be produced at the exhaust port of an engine which will reduce engine back pressure and improve exhaust port scavenging. The cross-sectional flow area of the set of holes **40** and the length of the baffle **34** are selected to produce a wave interference attenuation of a first range of frequencies in the engine exhaust. The second tube and hole set **68** therein along with the baffle **54** in the outer flow path **62** will attenuate a second range of frequencies in the engine exhaust. The set of holes **40** in the tube **23** are communicated with one end of the outer path **32** which has its opposite end joined to the in-between volume **18.** This produces a second reflected pulse which serves to broaden the negative pulse produced through the tuned tube **23** and reflected to the exhaust ports thereby to achieve a better scavenging effect at the exhaust ports of an engine connected to the inlet end **24** by exhaust pipe means.

The embodiment illustrated in FIGS. **1** thru **3,** is designed for use with vehicle engines operated at a constant engine speed range, for example, snowmobiles, tractors and the like which operate in the range of 5500 to 6500 rpm. The aforedescribed arrangement gives a good scavenging of engine exhaust in this range. Furthermore, the tube **23** also serves in cooperation with the baffle **34** and discontinuities at hole set **40** to produce sound attenuation as well as the aforedescribed reverse negative pulse for scavenging at the engine exhaust port. These combined functions reduce the overall length of previous silencer assemblies with such combined functions. The in-between volume **18** further serves to separate the wave interference discontinuities in the first and second sections **20, 22** to reduce noise turbulence at the discontinuities within the wave interference silencer sections of the assembly **10.** The first wave interference sections **20, 22** have a combined first and second effect to attenuate a wide range of sound frequencies. Thus, the arrangement is suitable for use in the exhaust system of internal combustion engines and is especially suited for use in exhaust systems for two-cycle internal combustion engines.

A second embodiment of the invention is illustrated in FIG. **4.** It includes an outer casing **74** having conically formed end closures **76, 78** at opposite ends thereof. As in the first embodiment of the invention, a first wave interference silencer **78** is located at the inlet end of the outer casing **74** closed by the closure **76.** It includes an open ended tube **80** having an inlet end **82** thereof adapted to be connected to an exhaust pipe of an engine. An annular extension flange **84** on the conical enclosure **76** engages the outer periphery of the tube **80** at the inlet end **82** thereof and is sealed with respect thereto by an annular weld segment **86.**

The outlet end **88** of the tube **80** is located immediately upstream of an open volume **90** in the outer casing **74** which is located upstream of the inlet end of a second wave interference assembly **92** located within the outer casing **74** upstream of the end closure **78.** The wave interference assembly **92** includes an open ended tube **94** of smaller diameter than tube **80** and located coaxially thereof. It includes an inlet end **96** located in alignment with the outlet end **88** of the tube **80** and an outlet end **98** that is adapted to be connected to a tailpipe of a vehicle. The outlet end **98** is supported by an annular flanged extension **100** on the conical enclosure **78** that engages the outer surface of the outlet end **98** and is sealed with respect thereto by means of an annular weld bead **102.**

As in the first embodiment, the length of the tube **80** is selected to produce a reflected negative pulse back to the inlet manifold of the engine for scavenging exhaust flow therefrom. Furthermore, it supports a helical baffle **104** on the outer surface thereof which has an inner edge **106** in engagement with the outer surface of the tube **80** and an outer edge **108** thereon in engagement with the inner surface of the outer casing **74.** The baffle **104** includes an inlet end **110** in communication with an annular cavity **112** formed by the closure **76** and an outlet end **114** at the in between volume **90.** The helical baffle **104** forms an elongated flow path **116** which winds around the outer circumference of the tube **80** to have a length greater than the length of the tube between the inlet end **110** and the outlet end **114** of the baffle **104.** The wave interference section **78** includes a set of openings **118** in the tube **80** at the location of the cavity **112.** These holes have a cross-sectional flow area approximately equal to the cross sectional flow area of the tube and serve as the entrance to the elongated path **116** formed by the helical baffle **104.** In accordance with known wave interference theory, the length of the path **116** is selected to produce an attenuation of a first frequency of sound in the engine exhaust as the exhaust passes through the wave interference section **78.** This silencing action is in addition to the function of the tuned tube **80** to produce a negative scavenging pulse at the exhaust port of the engine.

In this embodiment of the invention, the second wave interference silencer section **92** is modified as compared to the wave interference silencer section **54** in the first embodiment. It includes a second tube **120** located radially outwardly of and in spaced relationship to the tube **94.** Tube **120** is open ended and extends from the upstream end **96** of the tube **94** to a point immediately upstream of an annular cavity **122** formed by the end closure **78.** The annular cavity **122** is communicated through a set of holes **124** corresponding to the set of holes in the wave interference section **22** in the

embodiment of FIGS. 1–3. The section **92** includes a first helical baffle **126** extending about the outer surface of the tube **94** between the inlet end **96** thereof and the cavity **122.** It includes an inner edge **128** thereon in engagement with the outer surface of the tube **94** between the aforesaid mentioned points and an outer edge **130** that is in engagement with the inner surface of the tube **120** thereby to define an elongated helical groove or flow path **132** from the inlet end **96** of the tube **94** to the cavity **122.** Further, the assembly **92** includes an outer baffle **133** formed as a helix and wound around the outer surface of the tube **120** between the inlet end **134** thereof and the outlet end **136** thereof to the cavity **122.** The vane includes an inner edge **138** thereon in engagement with the outer surface of the support tube **120** and an outer edge **140** in engagement with the inner surface of the outer casing **92** to define an elongated helical flow path **142** from the open volume **90** to the cavity **122.** In this embodiment, the elongated paths **142, 132** within the wave interference silencer section **92** serve to attenuate three distinct ranges of sound frequencies in addition to the attenuation effect produced by the elongated flow path **116** in the wave interference silencer section **78.**

In this embodiment of the invention, the openings **118** serve to bridge the open volume **90** to spread the negative pulse produced by the power tuned tube **80** to improve scavenging effect and to produce less turbulence noise at the interacting areas defined by the openings **118, 124.**

While the embodiments of the present invention, as herein disclosed constitute a preferred form, it is to be understood that other forms might be adopted.

What is claimed is:

1. A silencer assembly for muffling noise and scavenging exhaust from an exhaust port of an engine comprising: an outer casing having an inlet end and an outlet end; a first open ended tube having one end located outside said casing and the other end thereof interiorly of said outer casing at the inlet end thereof to define a first outer flow path between said outer casing and said first tube, a second open ended tube having one end located outside said casing and the other end thereof directed interiorly of said outer casing at the outlet end thereof to define a second outer flow path between said outer casing and said second tube, said first and second tubes being located coaxially of one another and having open ends thereon located opposite one another in spaced relationship with respect to one another, said outer casing defining an open volume between said oppositely located open ends of said first and second tubes, a first wave interference helical baffle vane located within said first outer flow path having an inlet end and an outlet end in communication with said open volume, a second wave interference helical baffle vane located within said second outer flow path having an inlet end in communication with said open volume and an outlet end, means forming openings in said first tube communicating the interior of said tube with said first outer flow path at the inlet end of the first turn of said first helical baffle vane for producing a reflected wave from the open volume to the exhaust port of the engine, said first tube having a tuned length for producing a negative pressure at the exhaust port to reduce back pressure and to improve volumetric efficiency of the engine, said first interference helical baffle vane and said openings further serving to produce an interference wave for attenuating a first range of sound waves in said engine exhaust, said second tube having openings therein within said outer case in communication with the second outer flow path at the outlet end of said helical baffle vane to produce an interference wave to attenuate a second range of sound frequencies within said exhaust.

2. A silencer assembly comprising: an outer casing defining an interior volume, first wave interference means for directing exhaust into the interior volume of said outer casing, second wave interference means for directing exhaust from said interior volume of said outer casing, said first wave interference means including a first open ended inner tube with one end of said tube outside said casing and the other open end inside said casing and having a length to reflect an exhaust gas pressure pulse from the other open end of the first inner tube within the interior volume of the outer casing to the exhaust port of an engine to produce a negative pulse at the engine exhaust port for producing a scavenging effect, said second wave interference means including an open ended inner tube located coaxially of said first tube in spaced relationship therewith and defining an exhaust path from said outer casing, said first and second wave interference means each including a helical baffle defining a flow path located radially outwardly of each of said first and second tubes, said tubes and said outer flow paths being spaced apart from one another by an open volume within said interior volume of said outer casing, and holes within said first tube communicating with the inlet end of the outer path of said first wave interference silencer means to join with the open volume thereby to broaden the negative pulse at the exhaust port of an engine.

3. A power tuned silencer assembly comprising: an outer tubular casing having end closures to define a sealed interior volume, first wave interference means within one end of said volume including a first open ended tube with an inlet exterior of said casing and an outlet end located adjacent the midpoint of the interior volume of said outer casing, second wave interference means within said sealed volume including a second open ended tube located coaxially of said first tube and including an inlet end thereof located coaxially of the outlet end of said first tube in spaced relationship therewith within said outer casing and an outlet end exterior of said outer casing, said first tube having a length to produce a reflected wave from the interior volume to an engine exhaust port for producing a negative pulse at the engine exhaust port for scavenging an engine cylinder, said first wave interference means including means for attenuating a first range of sound frequencies in an engine exhaust, said second wave interference means including means for attenuating a second range of sound frequencies in the engine exhaust, said first interference means including a helical baffle on the exterior of said first tube to define an outer acoustical path open to said interior volume, said first tube having a plurality of openings at the inlet end thereof to intercommunicate said outer acoustical path and said sealed interior volume of said outer casing to broaden the negative pulse at the engine exhaust to improve scavenging of exhaust flow therefrom.

4. A power tuned silencer assembly comprising: an outer casing having closures on opposite ends thereof, a first open ended tube supported on one end of said outer casing centrally thereof, said first tube including

an inlet end exterior of said casing adapted to be connected to the exhaust pipe of an engine and an outlet end located within the interior of said outer casing, a second tube supported on the opposite end of said outer casing including an inlet end located in spaced relationship to the outlet end of said first tube and including an outlet end adapted to be connected to a tailpipe, said outlet end of said first tube and the inlet end of said second tube having an open space volume therebetween within said outer casing, means forming a plurality of openings in said first tube immediately downstream of said inlet end thereof at a point within said outer casing, said openings having a cross-sectional flow area approximately equal to the cross-sectional flow area of said first tube, means defining a second plurality of openings in said second tube adjacent the opposite end wall of said outer casing having a cross-sectional flow area approximately equal to the cross-sectional flow area of said second tube, a first helical baffle connected between the outer surface of said first tube and the inner surface of said outer casing including an inlet end in communication with said first plurality of openings and an outlet end in communication with said open space volume, a second helical baffle wound on the outer surface of said second tube and connected between said second tube and the inner surface of said outer casing including an inlet end in communication with said open space volume and an outlet end in communication with said second plurality of openings, said first tube having a length tuned to produce a reflected wave with a negative pulse at the exhaust port of an engine connected to the inlet end of said first tube for scavenging exhaust gases therefrom, said first plurality of holes communicating said outer path defined by said first baffle to join the in-between open space volume with said first tube interior at said openings to broaden the negative pulse of the reflected wave, said first tube and said first helical baffle in communication with said first plurality of openings further serving to attenuate a first range of sound frequencies in the engine exhaust, said second tube and said second wave interference baffle and said second plurality of openings serving to attenuate a second range of sound frequencies in the exhaust from the engine.

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