

[54] EXHAUST SYSTEM FOR A TWO-CYCLE ENGINE

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[51] Int. Cl. F01n 1/08, F02b 27/04

[58] Field of Search..... 60/273, 312, 314; 123/65 E; 181/53, 57

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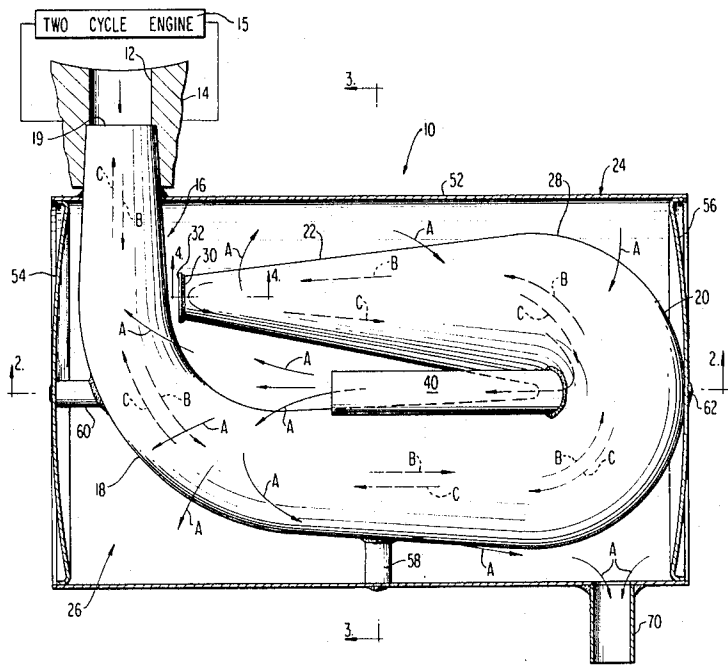
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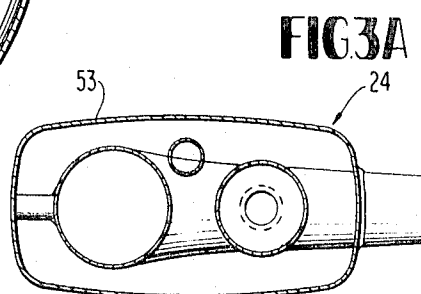
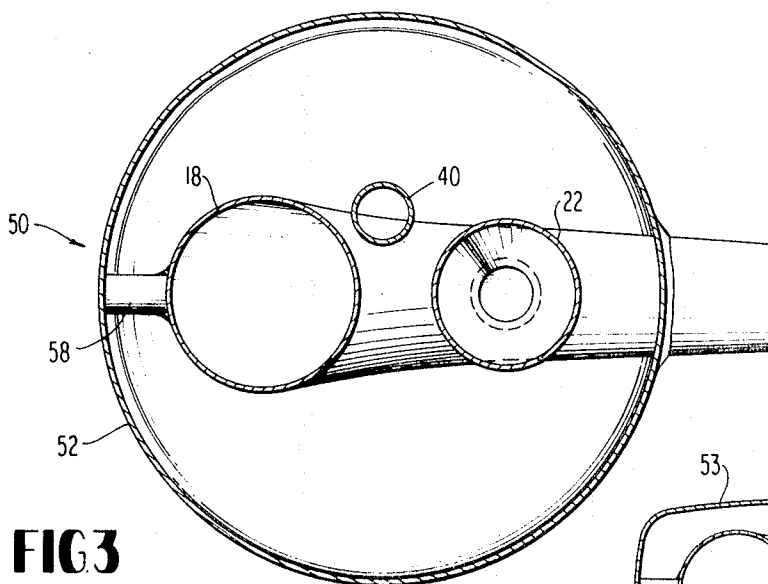
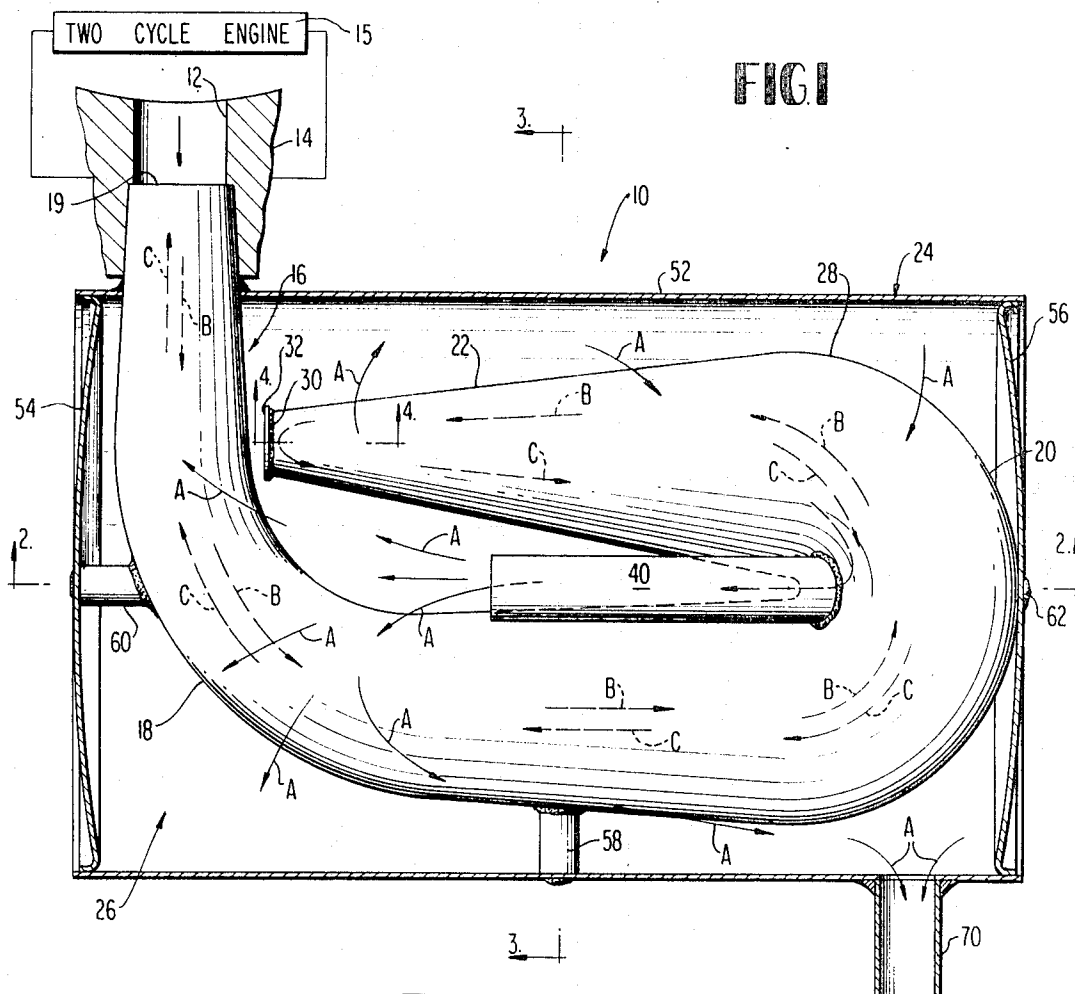
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[57] ABSTRACT

An exhaust system for a two-cycle engine having at least one working chamber with an exhaust port fashioned into the working chamber. The exhaust system includes a tubular member connected to the exhaust port for handling exhaust gases from the engine. The tubular member is constructed with an initial expansion section for providing an escape for gases during an initial scavenging phase of the chamber, a generally U-shaped section of generally constant cross-sectional area which bends the exhaust gases following the expansion phase, and a contraction section suitable to generate and reflect a positive pressure wave back to the exhaust port just prior to closing the exhaust port to retain combustible fluid within the working chamber during the final scavenging phase. A chamber completely encompasses the expansion section, U-shaped section and contraction section of the tubular member. An exhaust release port is fashioned into the tubular member to permit exhaust gases to enter the surrounding chamber. Noise producing fluid pulsations within the exhaust gases are attenuated within the closed chamber by being baffled over the exterior surface of the expansion section, U-shaped section and contraction section of the tubular member. The attenuated exhaust gases are then directed to the atmosphere through an exhaust conduit.

12 Claims, 6 Drawing Figures





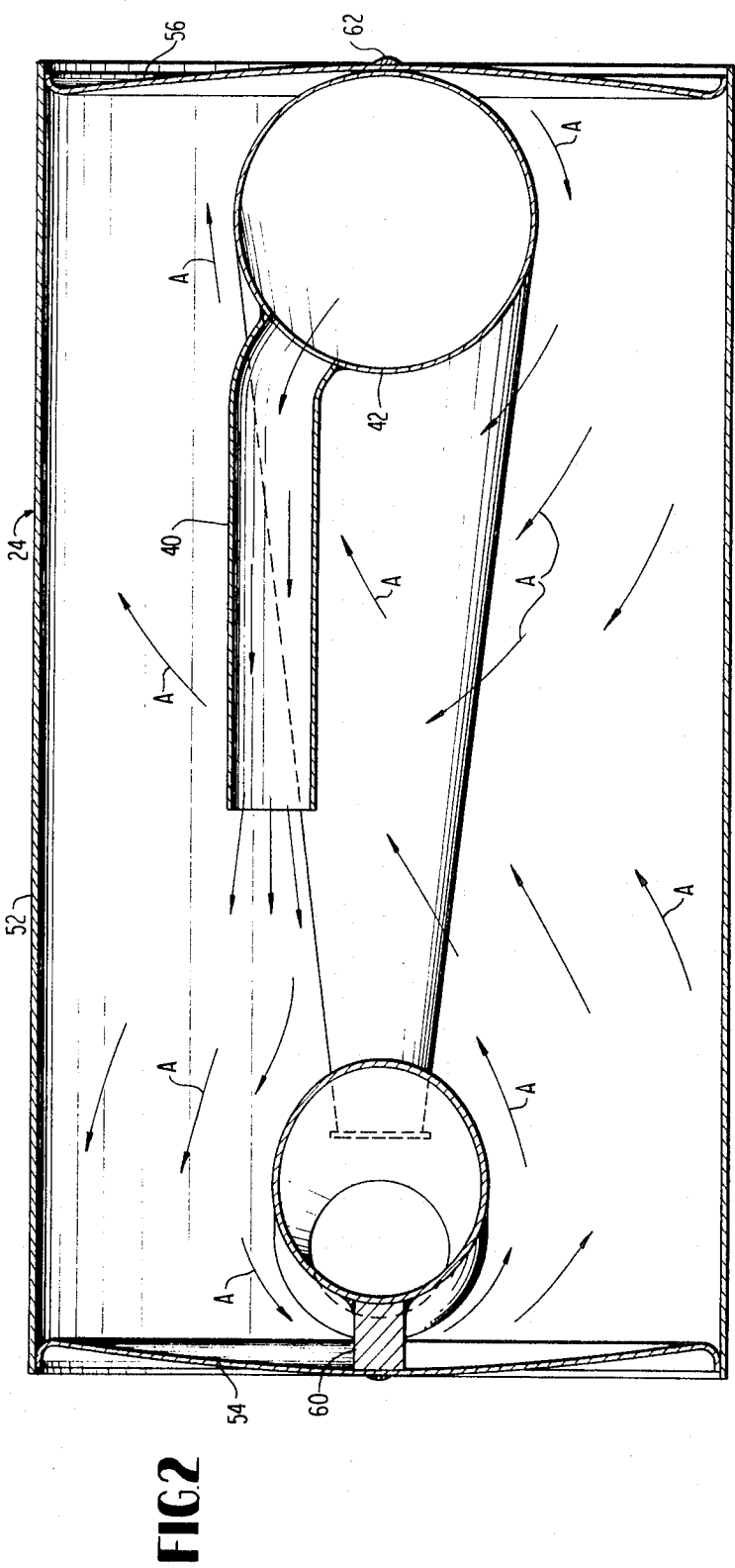


FIG 4

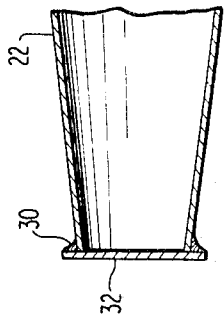
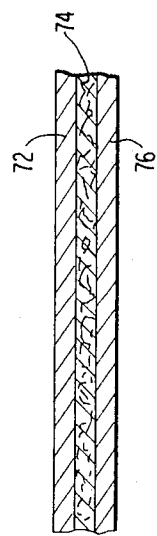


FIG 5



EXHAUST SYSTEM FOR A TWO-CYCLE ENGINE**BACKGROUND OF THE INVENTION**

This invention relates to an exhaust system for a two-cycle engine. More particularly the invention pertains to a compact tuned exhaust system for a two-cycle engine which will also maximize noise attenuation.

Two-cycle engines, typically, are designed such that exhaust and inlet ports are fashioned laterally into a working cylinder wall and are uncovered by reciprocation of the piston head within the working cylinder. The exhaust port is typically uncovered about 90° from top dead center during the power stroke. Between the time the exhaust port is uncovered and the piston reaching bottom depth center an intake port is uncovered. A fresh charge of combustible fluid and air is pushed into the cylinder through the inlet port to flush out combusted gas within the cylinder and provide a combustible charge for the next power stroke.

During the period of time when the exhaust port is initially opened, it would be desirable to maintain a low pressure condition adjacent to the exhaust port, so that the spent fluid may rapidly empty from the working chamber. Moreover during the scavenging phase when the inlet port is uncovered and the fresh charge is flushing the combusted fluid from the cylinder, it would be desirable to maintain a low pressure condition adjacent to the exhaust port. However, once the piston has reached bottom dead center and starts the compression stroke, it would be desirable to provide a high back pressure adjacent the exhaust port to prevent an excessive amount of combustible fluid from escaping through the exhaust port and into the exhaust system before the exhaust port is covered by the rising piston head.

In the past tuned exhaust systems have been disclosed for use with two-cycle engines which at least partially meet the above criteria by the utilization of an expansion cone within the exhaust system in combination with a contraction cone. Such a system is, for example, disclosed in a Burkhart U.S. Pat. No. 3,434,280 issued Mar. 25, 1969. By the provision of an exhaust system of this type, initial scavenging of the exhaust gases is facilitated by the expansion section while at the beginning of the compression stroke a positive pressure wave is reflected from the contraction section for providing a back pressure at the exhaust port. Such an exhaust system may be said to be "tuned" by a technique of "back stuffing".

While a tuned exhaust system such as disclosed in the Burkhart patent is at least theoretically desirable for use in connection with two-cycle engines, it has been found that such tuned exhaust systems often produce an objectionable noise level. Further, the size of such systems are often prohibitive for use with many devices, such as for example, snowmobiles, go-karts and the like.

In this connection a Tenney U.S. Pat. No. 3,665,712 issued May 30, 1972, discloses a two-cycle engine exhaust system which at least provides a degree of compactness and noise attenuation in conjunction with a tuned exhaust system. Notwithstanding, however, the laudible features of the previously known exhaust systems such as illustrated by the Burkhart and Tenney patents, room for significant improvement remains.

More specifically, it would be highly desirable to provide a compact tuned exhaust system for a two-cycle

engine with a higher level of noise attenuation than has been previously known. Additionally, it would be desirable to provide a simplified design which may be readily fabricated. Further, it would be desirable to reduce heat conduction between a tuned exhaust system and an exterior surface thereof.

OBJECTS AND SUMMARY OF THE INVENTION**Objects**

It is therefore a general object of the invention to provide an exhaust system for a two-cycle engine which will obviate or minimize problems of the type previously described.

It is a specific object of the invention to provide a novel exhaust system for a two-cycle engine which is suitable to simultaneously increase the brake horsepower and decrease the specific fuel consumption over that achievable by the utilization of a conventional exhaust system with a two-cycle engine.

It is another object of the invention to provide a novel tuned exhaust system for a two-cycle engine wherein the potentially audible fluid pulsations emanating from the exhaust system are minimized.

It is still another object of the invention to provide a novel tuned exhaust system for a two-cycle engine wherein the at least potentially audible fluid pulsations generated by the tuning portion per se of the exhaust system are attenuated.

It is yet another object of the invention to provide a novel tuned exhaust system for a two-cycle engine wherein the at least potentially audible fluid pulsations within exhaust gases from the tuning portion of the exhaust system are attenuated.

It is a further object of the invention to provide a novel tuned exhaust system for a two-cycle engine wherein the tuning section synergistically acts in concert with an encompassing chamber to attenuate potential audible fluid pulsations within the exhaust gases and fluid pulsations generated by the tuning section structure per se.

It is yet a further object of the invention to provide a novel tuned exhaust system for a two-cycle engine wherein the conduction of heat and the propagation of fluid pulsations exteriorly of an encompassing chamber are minimized.

It is still yet another object of the invention to provide a novel tuned exhaust system which is highly compact and rugged in design while simultaneously being highly effective in operation.

BRIEF SUMMARY

A tuned exhaust system for a two-cycle engine which is suitable to achieve at least some of the foregoing objects comprises a tubular tuned exhaust member including an expansion section, a generally U-shaped section and a contraction section. An outlet is provided in the tubular tuned exhaust member in the U-shaped section. A chamber encompasses the tuned tubular exhaust and is spaced therefrom. An outlet is provided in the chamber to permit exhaust gases to escape to the atmosphere.

The exhaust system effectively provides for noise attenuation by utilizing the tuned exhaust structure per se as a baffling system within the chamber and utilizing variant natural frequencies of the tuning exhaust member and the enclosed chamber to interfere and break up fluid pulsations within the chamber.

THE DRAWINGS

Other objects and advantages of the present invention will become apparent from the following detailed description taken in conjunction with the accompanying drawings, wherein:

FIG. 1 is a plan view of an exhaust system of the subject invention with an upper portion of an exterior chamber removed to disclose an interior tubular conduit having an expansion section, a U-shaped section, and a contraction section;

FIG. 2 is a cross-sectional view taken along section line 2—2 of FIG. 1;

FIG. 3 is a cross-sectional view taken along section line 3—3 in FIG. 1;

FIG. 3A is a cross-sectional view, similar in character to FIG. 3, of an alternate embodiment of the invention;

FIG. 4 is a detailed partial end view of the contraction section of the tubular member; and

FIG. 5 is an expanded detailed sectional view of an alternate wall composition of the exterior chamber disclosed in FIGS. 1—3.

DETAILED DESCRIPTION

Referring now to the drawings and, more particularly, to FIG. 1 thereof, there will be seen a broken away plan view of an exhaust system 10 according to the present invention.

The exhaust system 10 is connected to an exhaust port 12 of a working chamber or cylinder 14 of a conventional two-cycle engine. The working chamber and engine, per se, do not form a part of the subject invention, and therefore a detailed description of a conventional piston and cylinder combination is not believed necessary and is therefore represented schematically by a box 15. It will be appreciated, however, that the subject exhaust system is intended to be utilized within conventional two-cycle engines having a variety of designs and performance characteristics for a wide range of specific applications, such as for example, snowmobiles, concrete mixers, go-karts, compressors, etc.

The subject exhaust system 10 is connected directly to the exhaust port 12 of the working chamber 14 and includes a tubular member 16 having an expansion section 18, a generally U-shaped section 20, and a contraction section 22. The tubular member 16 is completely surrounded by a chamber 24 which will be discussed in detail hereinafter.

The expansion section 18 has a first end 19 of a cross-sectional area approximately equal with that of the exhaust port 12 of the working chamber. The expansion section 18 progressively increases in cross-sectional area from the end 24 toward the U-shaped section 20. For structural compaction purposes and also exhaust gas baffling purposes the expansion portion 18 of the tubular member 16 is provided with an approximately 90° bend generally in a mid-portion thereof in the general location 26.

The expansion portion 18 provides a means for the exhaust gas emanating from the working chamber 14 to immediately expand and therefore the pressure level at the exhaust port 12 will be reduced. This reduction in pressure permits exhaust gases to be readily expelled from the working chamber during the power stroke of the engine.

Downstream of the expansion section 18 and connected directly to the other end thereof is a generally U-shaped section 20 of approximately a constant cross-sectional area along its axial extent. A first end of the U-shaped section is integrally joined with the other end of the expansion section and a second end of the U-shaped section feeds directly into a downstream contraction section 22.

The U-shaped section serves to reverse in approximately an opposite direction the flow of the exhaust gases within the tubular member 16 to provide a compact arrangement and facilitate a baffling process to be discussed in detail hereinafter.

The contraction section 22 has a cross-sectional area at a first end thereof, integrally formed with the second end of the U-shaped member and thus of equal cross-sectional area. From that point, the cross-sectional area of the contraction section is increasingly diminished to the other end thereof. The end 30 of the contraction section is closed by a closure plate 32, note FIGS. 1 and 4.

The contraction section 22 serves to compress the molecules of gas and to reflect positive pressure waves back through the exhaust system to the exhaust port 12.

The overall axial length of the tubular member 16 is designed, in conjunction with the characteristics of the particular engine utilized and for a predetermined range of normal operating revolutions per minute, along with empirical factors such that a positive pressure wave is reflected back to the exhaust port 12 from the contraction section 22 just prior to closing of the exhaust port by the piston during the compression stroke. This positive pressure wave has a "back stuffing" effect in that combustible fluid entering the working chamber during the exhaust cycle is held in the working chamber by back pressure. The ultimate result is the prevention of losses of excessive amounts of combustible fuel into the exhaust system during the final phase of the scavenging process. It will be readily appreciated that by minimizing the amount of fuel that is lost during the exhausting phase of the engine operation the specific fuel consumption of the engine will be materially reduced. Moreover it has been determined that by facilitating exhaust gas scavenging and maintaining a greater charge within the cylinder the horsepower of the engine is increased.

In order to provide an avenue for exhaust gases to escape from the tubular member 16 a tap-off conduit 40 is connected into the inner bight portion 42 of the U-shaped section 20. At this location, the tubular member 16 is at its widest expanse and therefore the pressure is the lowest within the tubular member. As a result of tapping off at this location, exhaust gases are permitted to escape from the tubular member 16 at a minimum pressure.

Completely surrounding or encompassing the tubular member 16 and generally spaced therefrom is a chamber 24. The chamber 24 includes a generally cylindrical sidewall portion 52 with compatibly shaped end wall sections 54 and 56 to seal off the ends of the sidewalls 52. The chamber 24 is preferably generally circular in cross section for structural rigidity. This rigidity minimizes the tendency for propagating vibrations from within the chamber to the surrounding atmosphere.

While the circular cylindrical configuration is preferred for strength, and thus noise attenuation consid-

erations, in at least some instances increased compaction may be desired. In these instances the chamber 24 may be fabricated with a generally rectangular-elliptical cross-sectional configuration 53, note FIG. 3A.

The tubular section 16 and the chamber 24 may be advantageously fabricated from sheet steel or the like. Referring now to FIG. 5, however, there will be seen a detailed sectional view of a portion of an alternate construction of the side and end walls of the chamber 24. More particularly, a first lamina of metallic material 72 has juxtaposed to one surface thereof a lamina of insulating material A, such as asbestos. An outer lamina of metallic material 76 is then applied to the insulating material 74. This sandwich structure serves to minimize the conduction of heat through the lamina and further serves to minimize the transmission of vibrations from the inner wall 72 to the outer wall 76. In this manner, both heat and noise propagation exteriorly of the muffler system are minimized.

The tubular member 16 may be supported within the interior of the chamber 24 by the provision of normally extending cantilever braces 58 and 60 connected to the expansion section 18. Further, the U-shaped section may tangentially touch the end wall 56 and is supportingly welded thereto as at 62. Thus, the tubular member 16 is supported generally having the exterior surfaces thereof centrally within and spaced from the interior walls of the chamber 24.

Then chamber 24 is provided at a location remote from the tap-off conduit 40, with an exhaust conduit 70, note FIG. 1, for providing fluid communication between the chamber 24 and the atmosphere.

It will be appreciated by noting the flow arrows "A" within the interior of the chamber 24 that exhaust gases delivered from the tap-off conduit 40 will tend to swirl around the exterior surfaces of the folded tubular member 16 and finally exit through the exhaust port 70. This swirling or baffling of the exhaust gases within the chamber 24 about the exterior surfaces of the tubular member 16 serves to break up pressure waves within the exhaust gases and consequently attenuate noise-producing pulsations within the exhaust gas prior to entering the atmosphere. Thus, it will be appreciated that the conduit 16 synergistically provides an internal function of "back stuffing" to reduce the specific fuel consumption and increase the power output of the two-cycle engine and an external function in concert with the interior surface of the chamber 24 to attenuate potentially audible noise-producing fluid pulsations within the exhaust gas prior to delivery to the atmosphere.

In order to further attenuate fluid pulsations of the exhaust gases within the tubular member 16 the tubular member is constructed with a resonant frequency variant with respect to that of the chamber 24. Therefore, fluid pulsations produced by vibration from the members 16 and 24 will interfere and thus reduce the potential for creating pulsations of an audible magnitude.

Operation

Exhaust gases from the working chamber 14 are delivered through the exhaust conduit 12 into the expansion section 18 of the tubular member 16. In the expansion section, the gases expand and the pressure is reduced. By the provision of this reduced pressure at the exhaust port, combusted fluid within the working

chamber is effectively drawn into the exhaust system. Thus, scavenging combusted fluid from the working chamber is facilitated with a resultant increase in power output of the engine.

The exhaust gases travel through the tubular conduit 16, as illustrated by phantom directional arrows B. In this connection the gases are bent 90° in the expansion section and then 180 degrees through the U-shaped section 20. The gases are then condensed in the contraction section 22. This contraction sets up the propagation of high-pressure waves which travel in a counter direction, as illustrated, by phantom arrows C, back to the exhaust port to create a back pressure during the final exhaust gas scavenging process. By the provision of back pressure the possibility of combustible fuel being pushed into the exhaust system prior to closing of the exhaust ports is minimized.

In order to permit the system to operate on a continuous basis, exhaust gas is removed from the tubular member 16 through the tap-off conduit 40. As previously discussed, this conduit is tapped into the bight portion of the U-shaped member 20, and thus at an area of minimum pressure. The exhaust gases exit into the chamber 24 and immediately expand thus reducing the pressure thereof.

The exhaust gases are then baffled by flowing around the exterior surfaces of the folded tubular member 16 as depicted by directional arrows A. Baffling within the interior walls of the chamber 24 serves to effectively break up and attenuate air pulsations within the exhaust gas. Moreover, air pulsations generated by the vibration of the tubular member 16 and the chamber 24 interfere with each other and also with pulsations within the exhaust gases from the working cylinder to further attenuate fluid pulsations and minimize the propagation of audible noise as the exhaust gases exit from the port 70 into the atmosphere.

SUMMARY OF SOME OF THE MAJOR ADVANTAGES

By the provision of the foregoing method and apparatus, it will be appreciated that an exhaust system is provided for a two-cycle engine which will simultaneously increase the power output of the engine and decrease the specific fuel consumption over that possible by the utilization of a conventional muffler system.

Another significant aspect of the invention is the compactness of the design and the simultaneous synergistic co-action of a folded tubular tuning member and a cylindrical encompassing chamber for attenuating exhaust gas pulsations which may potentially be of an audible magnitude.

A further aspect of the invention is the provision of space between the exterior of the tubular member 16 and the interior of the chamber 24 so that exhaust gases may effectively expand within the chamber and flow around the exterior of the tubular member to break up air pulsations emanating from the tubular member 16. Still a further significant aspect is the provision of variant resonant frequencies of the chamber and tubular members to produce interfering fluid pulsation.

A yet further object of the invention is removing the exhaust gases from the tubular member at the bight of the U-shaped section where the pressure in the tubular member 16 is at a minimum.

A further significant aspect of the subject invention is the provision of a chamber which is circular in cross

section for rigidity and alternatively laminated including an intermediate heat and vibration barrier.

Although the invention has been described with reference to preferred embodiments, it will be appreciated by those skilled in the art that additions, deletions, modifications, and substitutions and other changes not specifically described may be made which will fall within the purview of the appended claims.

What is claimed is:

1. An exhaust system for a two-cycle engine having at least one working chamber with an exhaust port fashioned into said working chamber comprising:

a tubular member connected at one end in fluid communication with said exhaust port, and said tubular member including,

an expansion section fashioned with an increasing cross-sectional area from said one end of said tubular member for reducing pressure at said exhaust port of said at least one working chamber during an initial scavenging phase to aid in scavenging combusted fluid from said at least one working chamber,

a generally U-shaped section fashioned with a constant cross-sectional area and connected at one end to the other end of said expansion section to bend the flow of exhaust gas within said tubular member, and

a contraction section fashioned with a decreasing cross-sectional area connected at the large end thereof to the other end of said U-shaped section for reflecting pressure waves back through said tubular member to said exhaust port in said at least one working chamber to retard the flow of fluid from said at least one working chamber just prior to the closing of said at least one exhaust port whereby the retention of combustible fluid within the working chamber of said two-cycle engine may be optimized during a final scavenging phase to increase power output of said two-cycle engine;

closure means sealing the other end of said contraction section to assist said contraction section in reflecting pressure waves back to said at least one exhaust port in said at least one working chamber;

chamber means, encompassing said tubular member and dimensioned such that the interior of said chamber means is spaced from the exterior of said tubular member;

means for supportingly connecting said tubular member within the interior of said chamber means;

port means fashioned through a wall of said tubular member for providing fluid communication between the interior of said tubular member and the interior of said chamber means; and

an exhaust conduit connected into said chamber means for permitting exhaust gas to escape from said chamber means.

2. An exhaust system for a two-cycle engine as defined in claim 1 wherein said port means for providing fluid communication between the interior of said tubular member and the interior of said chamber means comprises:

a tubular conduit tapped into the inner bight portion of said generally U-shaped section for providing fluid communication between the interior of said tubular member and said chamber means at a loca-

tion within the tubular member of minimum pressure.

3. An exhaust system for a two-cycle engine as defined in claim 1 wherein:

said chamber means is generally cylindrical and circular in cross-section.

4. An exhaust system for a two-cycle engine as defined in claim 1 wherein:

said tubular member positioned within the interior of said chamber means has a resonant frequency variant from the resonant frequency of said chamber means whereby air pulsations within the interior of said chamber means may be attenuated.

5. An exhaust system for a two-cycle engine as defined in claim 1 wherein said chamber means comprises:

a laminated wall structure including an outer layer of metallic material an intermediate layer of insulation material, and an inner layer of metallic material, said layers being juxtaposed to minimize heat transfer and attenuate fluid pulsations between the inner and outer layers of the walls.

6. An exhaust system for a two-cycle engine as defined in claim 1 wherein:

said expansion section within the interior of said chamber means is provided with at least one 90° bend for providing a compact construction and fluid baffling structure to the interior of the chamber means.

7. An exhaust system for a two-cycle engine as defined in claim 6 wherein:

said exhaust conduit is connected into said chamber means in a position whereby at least said expansion section is intermediate said exhaust conduit and said port means fashioned into said tubular member within said chamber means whereby air pulsations with exhaust gases which exit from said port means are attenuated by passing at least around the exterior of said expansion section prior to entering the exhaust conduit.

8. An exhaust system for a two-cycle engine having at least one working chamber with an exhaust port fashioned into said working chamber comprising:

a tubular member connected at one end in fluid communication with said exhaust port and said tubular member including,

an expansion section fashioned with an increasing cross-sectional area from said one end of said tubular member for reducing pressure at said exhaust port of said at least one working chamber during an initial scavenging phase to aid in scavenging combusted fluid from said at least one working chamber,

a generally U-shaped section fashioned with a constant cross-sectional area downstream of said expansion section to bend in a generally opposite direction the flow of exhaust gas within said tubular member, and

a contraction section fashioned with a decreasing cross-sectional area downstream of said generally U-shaped section for reflecting pressure waves back to said exhaust port in said at least one working chamber to retard the flow of fluid from said at least one working chamber just prior to the closing of said exhaust port whereby the retention of combustible fluid within the working chamber of said

two-cycle engine may be optimized during a final scavenging phase;

a closure sealing the other end of said tubular member to assist said contraction section in reflecting pressure waves back to said exhaust port in said at least one working chamber;

a chamber positioned about and spaced from the exterior surface of said expansion section, said generally U-shaped section and said contraction section;

a tap-off conduit connected into the inner bight portion of said U-shaped section for providing fluid communication between the interior of said tubular member and the interior of said chamber for permitting exhaust gas to escape from said tubular member into the expanded volume of said chamber at a position of said tubular member of minimum pressure for minimizing pressure pulsations of the exhaust gases within said chamber;

an exhaust conduit connected into said chamber at a position remote from said tap-off conduit; and means for supporting said tubular member within the interior of said chamber whereby fluid pulsations within exhaust gases entering said chamber from said tap-off conduit may be attenuated by being baffled around said expansion section, said U-shaped section, and said contraction sections prior to being exhausted from said chamber.

9. An exhaust system for a two-cycle engine as defined in claim 8 wherein:

said expansion section is fashioned with at least one 90° bend and is positioned at least partially in front of the tap-off conduit of said tubular member.

10. An exhaust system for a two-cycle engine as defined in claim 8 wherein:

said chamber is generally cylindrical and circular in cross section.

11. A method for facilitating the handling of exhaust gases from a two-cycle engine having at least one working chamber with an exhaust port fashioned into said working chamber comprising the steps of:

delivering exhaust gas from the exhaust port into a tubular member, including an expansion section, a generally U-shaped constant cross-sectional section and a contraction section, and within the tubular member,

expanding said exhaust gases within the expansion section as said gases leave the working chamber to lower the back pressure at the exhaust port and aid in the scavenging of exhaust gases from the working chamber,

contracting the exhaust gases within the contraction section to generate positive pressure waves within the tubular member, and

reflecting the positive pressure waves back to the exhaust port just prior to closing of the exhaust port to minimize the flow of combustible fluid from the working chamber during a final phase of the scavenging process;

removing exhaust gas from an inner bight portion of the generally U-shaped section of the tubular member,

delivering the exhaust gas removed from the generally U-shaped section into a chamber completely encompassing the tubular member;

baffling the exhaust gas over the tubular member within the chamber to attenuate fluid pulsations in the exhaust gas; and

exhausting the attenuated exhaust gas to the atmosphere.

12. A method for facilitating the handling of exhaust gases from a two-cycle engine as defined in claim 11 wherein said tubular member is provided with at least one 90° bend in one portion thereof and at least one 180° bend in another portion thereof within the chamber, said step of baffling comprising:

conducting exhaust gases, over and around the exterior surfaces of the tubular member within the chamber to break up and attenuate fluid pulsations within the exhaust gases.

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