

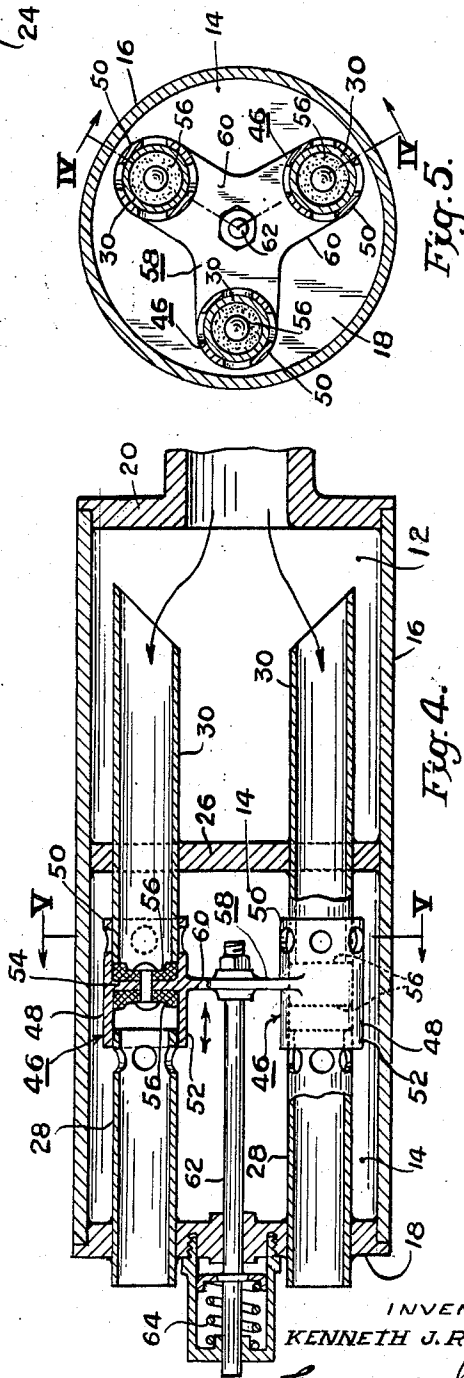
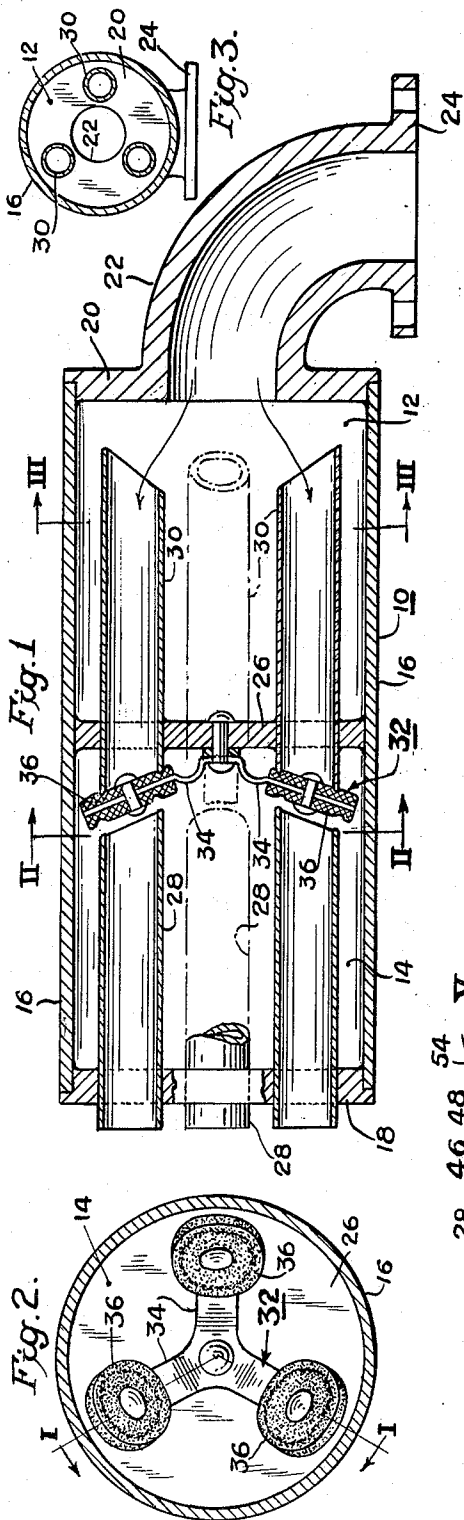
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MUFFLER APPARATUS

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MUFFLER APPARATUS

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This invention relates to mufflers for silencing the exhaust of internal combustion engines or the like.

A muffler which receives the pulsating exhaust gases discharged from an internal combustion engine is preferably capable of silencing the explosive sounds incident thereto without impeding gas flow to the extent of building up an appreciable gas pressure in the muffler. When back pressure is built-up in a muffler the exhaust pressure of the engine increases; and this prevents proper cylinder scavenging and vitiates the fresh intake charge in the cylinder, thereby decreasing engine efficiency.

One prior art muffler comprises a number of enclosed baffles providing a tortuous and restricted flow path for exhaust gases. This kind of muffler accomplishes silencing by reflecting sound waves within the muffler until they die out, but gas pressure builds up in the restricted flow path and lowers engine efficiency.

Another kind of prior art muffler provides a long straight flow path for exhaust gases which either builds up excessive back pressure or accomplishes insufficient silencing.

It is the principal concern of the present invention to silence exhaust noises by repeated reflection of sound waves within a muffler, without building up excessive gas pressure.

A muffler constructed according to the present invention comprises a shell having an inlet adapted for connection to the exhaust of an engine, an outlet, and it is provided interiorly with a plurality of chambers. One chamber is open to the inlet, another of the chambers is open to the outlet, and at least one passageway between these chambers is provided. Preferably, the cross-sectional flow area of the outlet and the cross-sectional flow area of the passageway are at least as large as the cross-sectional flow area of the inlet.

Further provided is a member, such as a two-way valve, which moves alternately between a first position in which the passageway is closed or obstructed and the outlet is opened or unobstructed and a second position in which the outlet is closed or obstructed and the passageway is opened or unobstructed.

With the present arrangement, sound waves produced by each explosion in the engine travel at a very high rate of speed, and they are reflected about the first chamber many times before the slower traveling exhaust gases approach the outlet of the passageway connecting the first and second chambers. During the time the sound waves are being reflected repeatedly about the first chamber and the gases are approaching the outlet of the passageway, the passageway is closed; but, after the passageway is subsequently opened to admit the gas to the second chamber, some of the sound waves which have not been attenuated in the first chamber are reflected through the passageway. However, the opening of the passageway is accompanied by the closing of the outlet, and those sound waves still remaining in the muffler which have passed through the passageway are reflected about the second chamber while gas is expanding therein. Still later, the opening of the outlet and the closing of the passageway allows the gas to escape to the atmosphere, at which time there are virtually no sound waves remaining capable of traveling through the outlet and being heard. It can be seen, therefore, that the use of a two-way valve, for example, in preference to a single acting valve, extends the time for reflecting sound waves about the muffler beyond the start of a gas pulsation to the end

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thereof, thus providing ample opportunity for the sound waves to die out by repeated reflection before they escape to the atmosphere.

In one embodiment of the invention, the member which moves alternately as just described includes a resonant member carrying a closure for the passageway and a closure for the outlet, which parts have a combined natural frequency calculated to vibrate as a result of being excited by alternating disturbances produced by the engine. acoustic shock waves, or gas pulsations. Any one of these disturbances may be employed to excite the desired vibration, or two or more of these disturbances may act in concert for the same purpose. In any event, a resonant condition requires very little energy to move the resonant member back and forth, with the result that engine power need not be utilized to move the resonant member.

In another embodiment of the invention, the two-way valve which opens and closes the passageway and opens and closes the outlet is moved by gas pressures, without dependence upon vibratory forces. In this type of arrangement, a biasing member such as a light spring is employed to normally close the passageway and normally open the outlet. Gas pressures are here sufficient to move the valve against the spring force toward a closed position with respect to the outlet and open the passageway at the same time. The gas then expands in the second chamber to a lower pressure which, though lower than the previous gas pressure in the passageway and higher than atmospheric pressure, is insufficient to prevent the valve from being returned under the force of its spring to its normally closed position with respect to the passageway. This alternative arrangement is also effective to extend the time for sound waves to be reflected about the interior of the muffler beyond the start of the gas pulsation; however, the use of gas pressure to operate the valve may result in some build up of gas pressure in the engine.

The various objects, features and advantages of the invention will appear more fully from the detailed description which follows, taken in connection with the accompanying drawing, forming a part of this application, in which:

FIG. 1 is a longitudinal sectional view taken on line I—I of FIG. 2 through a muffler constructed and arranged according to the invention;

FIG. 2 is a sectional view, taken along line II—II of FIG. 1, transversely through the shell of the muffler, and showing the two-way valves in full, but omitting the conduits with which valves are associated;

FIG. 3 is a reduced sectional view, taken transversely through the muffler shell along line III—III of FIG. 1;

FIG. 4 is a longitudinal sectional view similar to FIG. 1, taken on line IV—IV of FIG. 5, but showing the invention in modified form; and

FIG. 5 is a sectional view taken along line V—V of FIG. 4.

The invention, as shown, is applied to a muffler adapted to be connected to the exhaust port of an internal combustion engine. It includes a generally cylindrical shell 10 provided interiorly with an inlet chamber 12 and an outlet chamber 14. The shell 10 comprises a tubular, preferably cylindrical, wrapper member closed at the outlet end thereof by an end wall 18 in the form of an apertured circular plate. The wrapper member 16 is closed at the inlet end thereof by an end wall 20 in the form of a circular plate provided with an aperture to which is connected an elbow-shaped inlet tube 22. The tube 22 is preferably connected integrally to the end wall 20 and has a mounting flange 24 formed at the opposite end thereof. The mounting flange 24 permits the muffler to be secured to the engine block. The inlet chamber 12

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is separated from the outlet chamber 14 by means of a partition wall 26 disposed midway between the end walls 18 and 20.

The aperture in the inlet end wall 20 and the tube 22 provided the shell 10 with inlet means for admitting gas to the inlet chamber 12. The shell 10 is provided with an outlet in the form of a plurality of conduits 28, preferably three, which extend through the outlet end wall 18 and terminate inside the outlet chamber 14 adjacent the partition wall 26. The conduits 28 have an aggregated cross-sectional flow area substantially equal to the cross-sectional flow area of the inlet tube 22 so as not to restrict the flow of gases leaving the shell 10. The invention is not limited to the use of conduits as an outlet for the shell 10; however, it is desirable to use several conduits rather than one of them, in order to improve the quality of any sounds which might escape silencing in the muffler.

Providing a passageway between the inlet chamber 12 and the outlet chamber 14 are a plurality of pipes 30, preferably three, which extend through the partition wall 26 in alignment with the conduits 28. Opposite ends of each of the pipes 30 are respectively disposed in compartments 12 and 14, and the end of each pipe disposed in the outlet compartment 14 is in closely spaced relationship with the inlet end of its associated outlet conduit 28.

In order to control the flow of sound waves from chamber 12 to chamber 14 through the pipes 30, a two-way valve 32 is arranged in chamber 14 between the juxtaposed ends of each associated conduit 28 and pipe 30. Each valve 32 is a resonant member including a strip 34 of resilient material having pads 36 secured, as by a rivet, to the free end of the strip on opposite sides thereof. The material used for making the strip 34 may be Phosphor bronze which is capable of withstanding the temperatures of exhaust gases, for example, 600° F.; and yet it retains its resiliency. However, it is to be understood that the invention is not limited to any particular type of material. Likewise, the pads 36 may be made of any suitable material, but it is preferred that the pads be capable of absorbing shock when seating against the conduit or pipe; and for this purpose aluminum coated asbestos may be employed. The strips 34 may be made integrally and they are carried by the partition wall 26 whereon they are mounted in cantilever fashion, preferably secured at a common point as by a rivet.

The mounting of the two-way valves 32 is such that they normally close the end of the pipes 30 which terminate in the outlet chamber 14 under the biasing force of the resilient strip 34. The valves 32 normally open outlet conduits 28 when they are normally closing the pipes 30. When the valves 32 vibrate, they move from the normally closed position with respect to the pipes 30 to a second position wherein they open the pipes 30 to the outlet chamber 14 and close the outlet conduits 28. In the second position gas and sound waves are free to flow through the pipes 30 from the inlet chamber 12 to the outlet chamber 14, but they are prevented from exiting to the atmosphere.

For convenience of manufacture, the pipes 30 may be made of the same stock used for making the conduits 28. Also, it is preferred that they have the same cross-sectional flow area as the inlet tube 22 so as not to present a restriction in the muffler.

The two-way valves 32 have a natural frequency calculated to be excited by the frequency of the exhaust gas pulsations and/or the frequency of the acoustic shock waves caused by explosions in the engine and delivered to the muffler. The frequency of exhaust gas pulsations and the sound waves are usually the same, and in many engines there is one pulsation and one acoustic shock wave for each revolution of the engine. Consequently, it is contemplated that the tube 22 may act as a coupler through which mechanical vibrations produced in the en-

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gine will be transmitted to the muffler where they also may be employed to excite vibration of the valves 32. Depending upon the particular design of the engine and the muffler, the various disturbances which excite vibration of the valves 32 may be in or out of phase with respect to each other. This condition may be used to advantage to produce vibration of the valve over a wide range of engine operating speeds. For example, at one speed the frequency of the gas pulsations may excite vibration of the valves 32 and at another operating speed of the engine the acoustic shock waves and the gas pulsations may cooperate, partially nullifying each other and partially reinforcing each other, to produce still another exciting frequency corresponding to the natural frequency of the valves 32. Regardless of the source of excitation, it is well known that oscillating movement of a resonant member may be produced with very little energy when a resonant condition exists. Thus, movement of the valves 32 is accomplished with little or no expense to the deliverable power of the engine being silenced.

In operation, after each explosion in the engine, sound waves and a body of exhaust gas enter the muffler through the tube 22. Sound waves travel at a very high rate of speed, many times greater than the speed of the exhaust gases, and the sound waves have an opportunity to reflect repeatedly about the inlet chamber 12 and die out to a large extent even before the exhaust gases have undergone expansion in the inlet chamber and have begun to travel through the pipes 30. Some sound waves, however, bounce into the pipes 30 and travel therethrough with the exhaust gases; and even some of these sound waves are reflected back into the inlet chamber 12 after striking the pad 36 disposed at the end of the pipe 30.

When the valves 32 open to admit exhaust gases to the outlet chamber 14 the outlet conduits 28 are closed to the atmosphere. In this position those sound waves which enter the outlet chamber 14 have an opportunity to reflect about the outlet chamber 14 until such time as the vibrating valves 32 return to a closed position with respect to the pipes 30. When the valves 32 are open with respect to the outlet conduits 28 the exhaust gases are free to exit through the conduits to the atmosphere without having experienced a build up in pressure while traveling through the muffler flow paths.

It is to be understood that the valves 32 need not fully close the conduits 28 and/or the pipes 30 during their oscillating movement; but that the invention can be practiced by employing valves merely to alternately obstruct and unobstruct the ends of the pipes or conduits with which they are associated.

Referring now to FIGS. 4 and 5, a modified form of the invention will now be described in detail. Like reference numerals are employed to designate similar parts.

As in the previous embodiment of the invention, the conduits 28 and the pipes 30 are arranged in spaced relationship within the outlet chamber 14. And disposed between them is a tubular cup valve 46 which is fitted for sliding movement on the juxtaposed ends of associated conduits 28 and pipes 30. Each valve 46 comprises a sleeve member 48 extending substantially coaxially with the aligned conduit 28 and the pipe 30 with which it is associated. The sleeve member 48 includes an inner portion 50 which is perforated and receives the outlet end of the pipe 30, and it has an imperforate outer portion 52 which receives a perforated inlet end of the conduit 28. Between the inner portion 50 and outer portion 52 of the sleeve member 48 is disposed a closure 54 provided on opposite surfaces thereof with pads 56 for cushioning the shock when the valves seat. The arrangement is such that in a first position the outer portion 52 of the sleeve member uncovers the perforations in the inlet end of the outlet conduit 28, and at the same time the closure 54 closes the outlet end of the pipe 30, with the perforated inner portion 50 of the sleeve member 48 being in registry

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with an imperforate portion of the pipe 30. This is the position of the parts shown in FIG. 4. In a second position of the valve 46 (not shown) the outer portion 52 of the sleeve member 48 closes the perforations in the outlet conduit 28 and obstructs the flow of gas therethrough; and at the same time the inner portion 50 of the sleeve member 48 has its perforations in registry with the space between the juxtaposed ends of the conduit 28 and pipe 30 so as to unobstruct the outlet end of the pipe 30 to admit gas to the outlet chamber 14.

Each of the cup valves 46 are mounted on a spring biased carriage 58. The latter comprises a web member 60 to which all of the sleeve members 48 are connected and a rod 62 attached at one end thereof to the web member 60 and extending through the outlet end wall 18 for connection to a helical spring 64. The spring 64 exerts a bias on the carriage 58 that normally retains each cup valve 46 in its first position wherein the outlet end of the associated pipe 30 is closed.

In operation, gases admitted to the inlet chamber 12 are then conducted by the pipes 30 toward the outlet chamber 14. The force of the spring 64 holding the valves 46 in their normally closed position with respect to the pipes 30 yieldingly resist the gas pressures exerted on the valves 46. The gas enters the outlet chamber 14 and expands to a lower pressure, whereupon the spring 64 then operates to overcome gas pressure and returns the valves 46 to their normal position. The gases remaining in the outlet chamber 14 being at higher than atmospheric pressure, exit to the atmosphere.

The sound waves have been attenuated, as in the first embodiment, by repeated reflection about the inlet and outlet chambers until the valves 46 return to their normally closed position with respect to the pipes 30.

The embodiment of FIGS. 4 and 5 has the disadvantage of producing back pressure in the engine because gas pressure is required to move the valves 46. However, this arrangement has the advantage of effectively silencing exhaust noises with indifference to engine operating speed,

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and without dependence upon excitation of a resonant member by disturbances produced by the engine exhaust.

While the invention has been shown in two forms it will be obvious to those skilled in the art that it is not so limited, but is susceptible of various changes and modifications without departing from the spirit thereof.

What is claimed is:

1. An internal combustion engine having exhaust means and producing during operation a vibratory disturbance of a given frequency, a muffler having wall structure defining a plurality of chambers and including inlet means connected to said exhaust means, one of said chambers communicating with said inlet means, said muffler being provided with outlet means communicating with the other of said chambers, a passageway between said chambers, and a vibratory valve operatively associated with said passageway to alternately open and close said passageway, the natural frequency of vibration of said valve being substantially the same as the frequency of the vibratory disturbance produced by said engine.

2. The combination of claim 1 wherein said vibratory valve is connected to said wall structure, said wall structure is of rigid construction, and there being a rigid connection between said engine and said wall structure.

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