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(71) Applicant *(for all designated States except US)*: **EMCON TECHNOLOGIES LLC** [US/US]; 1209 Orange Street, Wilmington, Delaware 19801 (US).

(72) Inventors; and

(75) Inventors/Applicants *(for US only)*: **ABRAM, Kwin** [US/US]; 5666 East Homestead Drive, Columbus, Indiana 47201 (US). **KALYANASAMY, Govindaraj** [IN/US]; 13212 Salamone Way, Westfield, Indiana 46074 (US). **CALLAHAN, Joseph** [US/US]; 6160 Deerwood Drive, Greenwood, Indiana 46143 (US). **WILLATS, Robin** [GB/US]; 637 Greystone Court, Columbus, Indiana 47201 (US). **ARBUCKLE, Ivan** [GB/US]; 6092 Basswood Drive, Columbus, Indiana 47201 (US). **ISKENDEROVA, Kamilla** [US/US]; 3241 North Country Brook Street, Columbus, Indiana 47201 (US). **EGAN, James** [GB/US]; 2525 Central Avenue, Indianapolis, Indiana 46205 (US). **SHAW, Dennis** [US/US]; 640 Greystone Court, Columbus, Indiana 47201 (US).

(74) Agent: **LABA, Kerrie A.**; Carlson, Gaskey & Olds, 400 West Maple Road, Suite 350, Birmingham, Michigan 48009 (US).

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(54) Title: EXHAUST VALVE ASSEMBLY

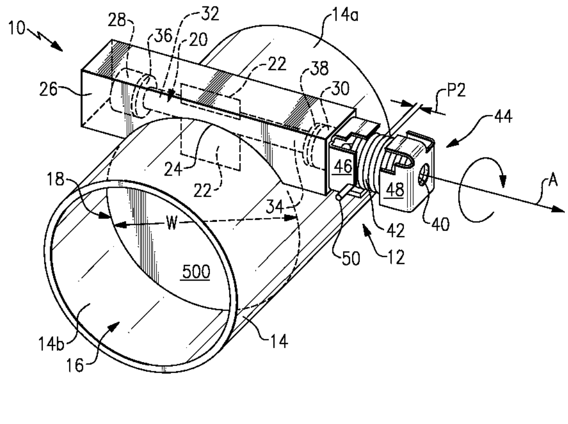

FIG.1

(57) **Abstract:** A vehicle exhaust system includes various exhaust components. A passive valve assembly is associated with at least one of the exhaust components. The passive valve is spring biased toward a closed position and is movable toward an open position in response to an increase in exhaust pressure that exceeds a biasing force of the spring. One aspect of the invention relates to a location of the passive valve in relation to other exhaust system components. Another aspect of the invention relates to the passive valve in combination with a packed resonator. Another aspect of the invention relates to the passive valve including a stop pad that facilitates noise reduction while also improving valve performance and durability. Another aspect of the invention relates to using the passive valve in a non-bypass configuration with a high percentage of coverage when in a closed position. Another aspect of the invention relates to providing an offset passive valve configuration in the vehicle exhaust system.

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EXHAUST VALVE ASSEMBLY

RELATED APPLICATIONS

[0001] This application claims priority to provisional application number 60/989,508 filed on November 21, 2007; U.S. patent application 11/950,034, filed on December 4, 2007; U.S. patent application 11/969,936, filed on January 7, 2008; U.S. application 11/953,930, filed on December 11, 2007; U.S. patent application 12/013,652, filed on January 14, 2008; and U.S. patent application 11/964,062, filed on December 26, 2007.

TECHNICAL FIELD

[0002] The subject invention relates to a valve assembly for a vehicle exhaust system. One aspect of the invention relates to a location of a passive valve in relation to other exhaust system components. Another aspect of the invention relates to a passive valve and resonator configuration, and more particularly relates to a passive valve in combination with a packed resonator. Another aspect of the invention relates to a passive valve with a stop pad that facilitates noise reduction while also improving valve performance and durability. Another aspect of the invention relates to a passive valve in a non-bypass configuration with a high percentage of coverage when in a closed position. Another aspect of the invention relates to passive valve that is offset within a vehicle exhaust system.

BACKGROUND OF THE INVENTION

[0003] Exhaust systems are widely known and used with combustion engines. Typically, an exhaust system includes exhaust tubes that convey hot exhaust gases from the engine to other exhaust system components, such as mufflers, resonators, etc. Mufflers and resonators include acoustic chambers that cancel out sound waves carried by the exhaust gases. Although effective, these components are often relatively large in size and provide limited nose attenuation.

[0004] Passive valves have been used in a muffler to provide further noise attenuation. However, the proposed valves have numerous drawbacks that limit their widespread use in a variety of applications. One disadvantage with passive valves is their limited use in high temperature conditions. Another disadvantage with known passive valve configurations is that these valves do not effectively attenuate low frequency noise. Further, additional challenges are presented when these types of valves are used in exhaust systems with multiple mufflers.

[0005] Attempts have been made to improve low frequency noise attenuation without using passive valves by either increasing muffler volume or increasing backpressure. Increasing muffler volume is disadvantageous from a cost, material, and packaging space perspective. Increasing backpressure can adversely affect engine power.

[0006] One solution is to locate the passive valve outside of the muffler. An example of such a configuration is found in applicant's co-pending application 11/950,034 filed on December 4, 2007. While this solution has proven to be effective, other challenges are presented within the overall exhaust system by this type of mounting arrangement. A position of the passive valve in relation to other exhaust system components becomes an important characteristic from a noise reduction perspective. A specific position of the passive valve in the overall exhaust system is directly tied to the acoustic effectiveness of the valve. For example, positioning the valve at an acoustic velocity nodal point is ineffective. Additional challenges are also presented by multi-exhaust component systems, such as systems that include more than one muffler for example. Positioning the passive valve in front of a main muffler can give rise to chatter issues due to a higher level of pressure pulsations.

[0007] Still other attempts have been made to use the passive valve in the exhaust system at a location outside of a muffler. For example, the passive valve has been used within an exhaust pipe with a by-pass configuration. The passive valve includes a flapper valve body or vane that is positioned within the exhaust pipe, with the vane being pivotable between an open position and a closed position. The passive valve is spring biased toward the closed position, and when exhaust gas pressure is sufficient to overcome this spring bias, the vane is pivoted toward the open position. In by-pass configurations, the vane provides 100% coverage, i.e. complete blockage, of the exhaust component when in the closed position. When closed, exhaust gases can flow outside of the exhaust pipe that houses the vane via a by-pass pipe that is connected to the exhaust pipe at locations upstream and downstream of the vane. The vane is generally configured such that, during pivotal movement, edges of the vane do not contact inner surfaces of the exhaust component. While use of such a valve improves low frequency noise attenuation, there is additional flow noise caused by turbulence generated at edges of the vane. Thus, while using the passive valve outside of the muffler has addressed certain problems, it has raised additional noise challenges that need to be addressed.

[0008] Further, due to the use of the spring, it is difficult to return the vane to a consistent closed position within the exhaust pipe. Also, the use of the spring introduces additional noise challenges for the passive valve. For example, when the spring returns the vane to the closed position, closing noise is generated, which is undesirable.

[0009] Additionally, when the passive valve is used within an exhaust pipe, such as a pipe in a muffler or when used in a by-pass pipe configuration, challenges are presented when the passive valve is moved toward a fully open position. When the vane is moved toward the fully open position, potential interference challenges are presented by the shape of the pipe itself. Traditionally, the vane has been supported by a shaft mounted to a wall of the pipe, with the shaft defining a pivot axis of rotation that is aligned with the vane, i.e. a plane defined by the vane intersects the pivot axis of rotation. The pipe typically includes a curved pipe wall having an inner surface that defines the exhaust gas flow path. When the vane is pivoted near this wall surface of the pipe, an opening angle for the passive valve is limited by the width of the vane and the curvature of the wall. Limiting the opening angle is disadvantageous from a back pressure standpoint, in addition to failing to achieve a true fully open position for maximum flow.

[0010] Also, as known, a muffler is subjected to different operating conditions dependent upon application. For example, due to its usual position, a main muffler for a passenger car can be subjected to exhaust gases of 600 degrees Celsius, while mufflers used in truck, minivan or SUV applications are subjected to gas temperatures that can exceed 750 degree Celsius.

[0011] In passenger car applications, a passive noise attenuation valve has been directly incorporated within a muffler body to provide noise attenuation. This valve includes a spring for biasing a valve body for pivotable movement within a valve housing that defines an exhaust flow path. The spring has limited application in high temperature environments. Special high-temperature spring materials are often required, which can be very expensive.

Also, these valves can be difficult to package in smaller sized mufflers, which are typically used as part of a multi-muffler configuration for larger vehicles such as trucks, SUVs, mini-vans, etc.

[0012] Typically, these known passive valves are used in a configuration where a by-pass flow path is provided. As discussed above, this type of configuration has a primary flow path and a by-pass flow path for exhaust gases. The valve body is positioned within an internal muffler tube that defines the primary flow path. As discussed above, the valve body is configured to block 100% of the primary flow path when in the closed position. A by-pass tube is in fluid communication with the internal muffler tube at a position upstream of the valve body and at a position downstream of the valve body. Under certain conditions, such as when the primary flow path is 100% blocked for example, exhaust gases are directed around the valve body via the by-pass tube.

[0013] Providing by-pass flow paths is disadvantageous from an assembly, material, and weight perspective. Further, as discussed above, it is difficult to package these valves in smaller mufflers, and these valves are not able to operate effectively in high temperature environments. Attempts have also been made to use a non-bypass configuration with an actively controlled, vacuum operated valve configuration. However, this is disadvantageous from a cost and packaging perspective.

[0014] Therefore, there is a need to provide an exhaust system and passive valve arrangement that can effectively attenuate low frequency noises without introducing other types of noise issues. Further, there is a need to provide a passive valve arrangement that can effectively and efficiently return a vane to a consistent closed position from a fully open position without generating additional noise, and closing forces should be minimized to improve durability of the passive valve.

[0015] This invention addresses these needs while avoiding the shortcomings and drawbacks of the prior art.

SUMMARY OF THE INVENTION

[0016] A vehicle exhaust system includes a passive valve that is positioned within the exhaust system at a certain positional relationship to other exhaust components to provide a significant acoustic advantage of noise attenuation for the exhaust system as a whole.

[0017] In one example, a vehicle exhaust system includes at least one muffler having an inlet and an outlet. A first pipe body is connected to the outlet and a second pipe body is connected to the inlet. A passive valve assembly is mounted within one of the first and second pipe bodies and is positioned at a location within a first 25% of an overall pipe length of a respective one of the pipe bodies relative to corresponding one of the inlet and outlet of the muffler.

[0018] In one example, the first pipe body has first and second ends. The first end is located at the muffler, and the pipe body extends to a second end to define the overall pipe length. The first pipe body defines a sole exhaust flow path between the first and the second ends. A passive valve assembly is mounted within the first pipe body and is positioned at a location within a first 25% of the overall pipe length relative to the first end, which is positioned at the outlet of the muffler.

[0019] In one example, the vehicle exhaust system includes at least first and second mufflers and an inter-pipe that connects the first muffler to the second muffler. The inter-pipe defines a sole exhaust gas flow path between the first and the second mufflers. The inter-pipe has a tube body with a first end connected to the first muffler and a second end connected to the second muffler. The tube body extends from the first end to the second end to define an overall inter-pipe length. The passive valve assembly is mounted within the tube body at a position between the first and the second ends. The passive valve assembly is positioned at a location within a first 25% of the overall pipe length relative to one of the first and the second ends.

[0020] In these examples, by positioning the passive valve assembly within the first 25% of the overall length as defined, the valve is close to the velocity anti-node position for acoustic resonances that exist within the associated pipes.

[0021] In another example configuration, a vehicle exhaust system includes first and second exhaust components with an inter-pipe that fluidly connects an outlet of the first exhaust component to an inlet of the second exhaust component. A passive valve is mounted within the inter-pipe. The second exhaust component defines an internal cavity that is at least partially packed with a high frequency absorption material. This packed configuration cooperates with the passive valve to effectively attenuate low and high frequency noise.

[0022] In one example, the first and the second exhaust components comprise first and second mufflers or resonators and the inter-pipe comprises a sole exhaust gas flow path between the first outlet and the second inlet.

[0023] In one example, the first exhaust component has a first inlet and a first outlet, and the second exhaust component defines an internal cavity that has a second inlet and a second outlet. The second inlet and the second outlet cooperate to define an internal flow path through the second exhaust component. The internal flow path occupies a portion of the internal cavity leaving a remaining portion. The remaining portion of the internal cavity is completely packed with a high frequency absorption material. The inter-pipe connects the first outlet with the second inlet, and the passive valve is mounted within the inter-pipe.

[0024] In one example, the second exhaust component includes a pipe that connects the second inlet to the second outlet to define the internal flow path. The pipe is defined by a pipe diameter and the passive valve is mounted within the inter-pipe at a specified distance from the second inlet of the second exhaust component. In one example, this specified distance is a distance that is at least four times the pipe diameter of the internal flow path.

[0025] In one example, the pipe includes a perforated section and the high frequency absorption material is positioned within the internal cavity to contact at least a portion of the perforated section. In one example, the high frequency absorption material contacts an entire length of the perforated section.

[0026] The above-described combination of a passive valve and an associated packed muffler cooperate to effectively attenuate low and high frequency noises. The use of the passive valve within a non-bypass inter-pipe provides very effective low frequency noise attenuation while the use of the packed rear positioned muffler addresses noise issues created due to the passive valve location and configuration.

[0027] In another example exhaust system configuration, a passive valve includes a vane that is positioned within an exhaust gas flow path. The vane is supported by a shaft and is pivotable between open and closed positions. A stop is also positioned within the exhaust gas flow path and defines a closed position for the vane.

[0028] In one example, the vane comprises a body structure that has a first portion coupled to the shaft. The body structure extends from the first portion to a tip. When in the closed position, the tip of the body structure engages the stop. In this configuration, the stop is positioned furthest from an axis of rotation defined by the shaft. This reduces contact forces between the stop and the vane to provide improved durability.

[0029] In one example, the stop comprises a ramped surface that begins upstream of the vane. An exhaust component has a wall with an external surface and an internal surface that defines the exhaust gas flow path. The ramped surface extends from the internal surface of the wall toward the vane. A stop end surface then extends from the ramped surface back toward the internal surface of the wall. The tip of the vane engages the stop end surface when the passive valve is in the closed position. The upstream ramped surface reduces backpressure, turbulence, and the generation of flow noise.

[0030] In another example exhaust system configuration, a passive valve for a vehicle exhaust system is arranged in a non-bypass configuration and provides a high percentage of coverage when in a closed position.

[0031] In one example, the passive valve assembly is mounted within an exhaust tube. The exhaust tube has a bore that defines an exhaust flow path having a cross-sectional area. One end of the exhaust tube is to be connected to a first exhaust component and a second end of the exhaust tube is to be connected to a second exhaust component such that the exhaust tube forms a sole exhaust path between the first and the second exhaust components. The passive valve assembly includes a vane that is mounted within the bore, and which is moveable between an open position and a closed position. A resilient member biases the vane toward the closed position. When the vane is in the closed position, the vane covers 80-97% of the cross-sectional area.

[0032] As such, a high-coverage single passive valve assembly is used in a non-bypass arrangement to effectively attenuate low frequency noise.

[0033] In another example exhaust system configuration, an exhaust component includes a wall with an inner surface defining an exhaust gas flow path. A passive valve assembly includes a vane that is positioned within the exhaust gas flow path to be pivotable between open and closed positions. The vane is defined by a plane that extends across a width of the vane. The vane is supported by a shaft that defines an axis of rotation. The axis of rotation is offset from the plane of the vane.

[0034] In one example, the exhaust component comprises a pipe having a curved inner wall surface. A housing is mounted to a curved outer surface of the pipe. At least one bushing is mounted within the housing to pivotally support the shaft. A resilient member biases the vane toward the closed position, and the vane is pivoted from the closed position towards the open position in response to an exhaust gas flow that exceeds a biasing force of the resilient member.

[0035] In one example, the plane and the axis of rotation have a non-intersecting relationship and a connecting arm is used to maintain a spaced relationship between the plane and the axis of rotation. The connecting arm has one portion coupled to the shaft and another portion coupled to the vane. The connecting arm extends transversely to the plane and to the axis of rotation.

[0036] In one example, the vane comprises a disc-shaped body having a greater width than thickness. The plane is defined across the width of the disc-shaped body.

[0037] By offsetting the plane from the vane, the vane can be pivoted to a fully open position to maximize flow without interfering with a curved inner surface of the wall of the pipe.

[0038] These and other features of the present invention can be best understood from the following specification and drawings, the following of which is a brief description.

BRIEF DESCRIPTION OF THE DRAWINGS

[0039] Figure 1 shows a perspective view of an exhaust pipe component and passive assembly.

[0040] Figure 2 shows an acoustic velocity mode shape for a pipe having open ends.

[0041] Figure 3 shows one example of a passive valve in a vehicle exhaust system.

[0042] Figure 4 shows another example of a passive valve in a vehicle exhaust system.

[0043] Figure 5 shows another example of a passive valve in a vehicle exhaust system.

[0044] Figure 6 shows one example of a passive valve in a vehicle exhaust system.

[0045] Figure 7 shows a cross-sectional view of a rearmost exhaust component from Figure 6.

[0046] Figure 8 shows a schematic view of a mounting location of the passive valve in relation to the exhaust component of Figure 7.

[0047] Figure 9 is a schematic view of one example of a packed exhaust component with a perforated pipe.

[0048] Figure 10 is a schematic view of another example of a packed exhaust component with a tuning pipe.

[0049] Figure 11 shows a perspective view of one example of an exhaust component and passive valve assembly.

[0050] Figure 12 shows a side view of an exhaust component with a stop for a vane.

[0051] Figure 13A is a schematic side view showing a ramp surface angle of the stop relative to a centerline of the exhaust component.

[0052] Figure 13B is a schematic side view showing an end surface angle of the stop relative to the centerline of the exhaust component.

[0053] Figure 14 is a schematic side view of one example of a stop.

[0054] Figure 15 is a schematic side view of another example of a stop.

[0055] Figure 16A is a perspective view of another example of a stop.

[0056] Figure 16B is an end view of the stop of Figure 16A.

[0057] Figure 16C is a side view of the stop of Figure 16A.

[0058] Figure1 6D is a top view of the stop of Figure 16A.

[0059] Figure 17 shows a schematic view of a valve shaft, bushings, and spring as used in the assembly of Figure 1.

[0060] Figure 18 shows a cross-sectional view of the spring of Figure 17.

[0061] Figure 19 is a schematic side view of a spring and vane showing substantially closed and open positions.

[0062] Figure 20 is a cross-sectional end view of an external exhaust tube and passive valve assembly with the vane being in the substantially closed position.

[0063] Figure 21 is a perspective view of a muffler and an external exhaust tube with a passive valve assembly.

[0064] Figure 22 shows a side view of an exhaust component with an offset vane.

[0065] Figure 23 is a schematic side view of the exhaust component of Figure 22 in a fully open position.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

[0066] As shown in Figure 1, an exhaust component, such as an exhaust tube or pipe 10 includes an exhaust throttling valve, referred to as a passive valve assembly 12. The passive valve assembly 12 is movable between an open position where there is minimal blockage of an exhaust gas flow path 16 and a closed position where a substantial portion of the exhaust gas flow path 16 is blocked. The passive valve assembly 12 is resiliently biased toward the closed position and is moved toward the open position when exhaust gas flow generates a pressure sufficient enough to overcome the biasing force.

[0067] In the example shown, the exhaust pipe 10 comprises a single tube body 14 that defines the exhaust gas flow path 16. The passive valve assembly 12 includes a valve body or vane 18 that blocks a portion of the exhaust gas flow path 16 when in the closed position. As discussed above, the vane 18 is pivoted toward the open position to minimize blockage of the exhaust gas flow path 16 in response to pressure exerted against the vane 18 by exhaust gases.

[0068] In one example, the vane 18 is fixed to a shaft 20 with a tang, bracket, or connecting arm 22. A slot 24 is formed within an outer surface of the pipe body 14. A housing 26, shown in this example as a square metal structure, is received within this slot 24 and is welded to the pipe body 14. Other housing configurations could also be used. The shaft 20 is rotatably supported within the housing 26 by first 28 and second 30 bushings or bearings. In the example shown, the connecting arm 22 comprises a piece of sheet metal that has one portion welded to the shaft 20 and another portion that extends outwardly from the housing 26 and is welded to the vane 18. Thus, the vane 18 and the shaft 20 pivot together about an axis A that is defined by the shaft 20. The connection arm 22 is just one example of how the shaft 20 can be attached to the vane 18, it should be understood that other attachment mechanisms could also be used.

[0069] The first bushing 28 is positioned generally at a first shaft end 32. The first bushing 28 comprises a sealed interface for the first shaft end 32. The shaft 20 includes a shaft body 34 that has a first collar 36 and a second collar 38. The first bushing 28 includes a first bore that receives the first shaft end 32 such that the first collar 36 abuts directly against an end face of the first bushing 28 to provide a sealed interface. As such, exhaust gases cannot leak out of the first bushing 28 along a path between the shaft 20 and first bushing 28.

[0070] The second bushing 30 includes a second bore through which the shaft body 34 extends to a second shaft end 40. The second collar 38 is located axially inboard of the second bushing 30. The shaft 20 extends through the second bore to an axially outboard position relative to the second bushing 30. A resilient member, such as a spring 42 for example, is coupled to the second shaft end 40 with a spring retainer 44. The spring retainer 44 includes a first retainer piece 46 that is fixed to the housing 26 and a second retainer piece 48 that is fixed to the second shaft end 40. One spring end 50 is associated with housing 26 via the first retainer piece 46 and a second spring end (not viewable in Figure 1 due to the spring retainer 44) is associated with the shaft 20 via the second retainer piece 48.

[0071] The passive valve assembly 12 is advantageously positioned within a vehicle exhaust system at a certain positional relationship to other exhaust components to provide a significant acoustic advantage for overall noise attenuation. Figure 2 schematically shows a pipe 60 having open ends 62, 64. A typical acoustic velocity mode shape for this pipe configuration is shown at 66. It has been found that where the passive valve assembly 12 is positioned within an exhaust system determines its acoustic effectiveness. For example, positioning the passive valve assembly at an acoustic velocity nodal point P (Figure 2) is ineffective for noise attenuation.

[0072] One example of a vehicle exhaust system 70 is shown in Figure 3. This configuration includes at least one muffler 72 that has an inlet 74 that receives exhaust gas flow from an engine as indicated at 76. The muffler 72 can comprises the only muffler in the vehicle exhaust system 70 or, if other mufflers are included in the vehicle exhaust system 70, the muffler 72 comprises a rearmost muffler in the vehicle exhaust system 70. The muffler

72 includes an outlet 78 that directs exhaust gases to a tailpipe 80. The outlet 78 can comprise a tube 82 that is coupled to a rear of the muffler 72 and coupled to the tailpipe 80, or the tube 82 can comprise the tailpipe 80 itself.

[0073] In either configuration, the tube 82 forms the sole exhaust gas flow path between the muffler 72 and an outlet from the tailpipe 80, and the passive valve assembly 12 is the only valve located within this section of the exhaust system. In other words, there is no by-pass tube or path downstream of the muffler 72 for this configuration. As such, the tube 82 is defined as having a first end 84 that is coupled to the outlet 78 and a second end 86 that extends to the outlet from the tailpipe 80. The tube 82 has an overall length that extends from the first end 84 to the second end 86. This overall length is referred to as a developed length of the pipe or tube. The overall length does not have to be a straight-line length, i.e. the first 84 and second 86 ends can be non-coaxial, and the overall length can be defined as a length that is comprised of straight and curved portions added together.

[0074] In the example shown, a passive valve assembly 12a is mounted outside of, i.e. external to, the muffler 72 and within the tube 82 at a position between the first 84 and second 86 ends. To provide the most effective noise attenuation, the passive valve assembly 12a is positioned at a location within a first 25% of the overall pipe length relative to the first end 84 as indicated at 90a. By locating the passive valve assembly 12a in this location, the acoustic attenuation benefit of positioning the valve assembly 12a close to the velocity anti-node positions for the acoustic resonances existing within the tube 82 is provided.

[0075] In an alternate location, a passive valve assembly 12b is located within a tube or pipe 75 that is fluidly connected to the inlet 74 of the muffler 72. This pipe 75 defines an overall pipe length and comprises a sole exhaust flow path between the muffler 72 and an upstream exhaust component. The passive valve assembly 12b is positioned at a location within a first 25% of the overall pipe length relative to the inlet 74 as indicated at 90b.

[0076] Figure 4 shows another example of a vehicle exhaust system 90. In this configuration, there is a first muffler 92, a second muffler 94 and an inter-pipe 96 connecting the first 92 and second 94 mufflers. The inter-pipe 96 comprises the sole gas path between the first 92 and second 94 mufflers, i.e. a non-bypass configuration is provided, and the passive valve assembly 12 is the only valve located within this section of the exhaust system.

The inter-pipe 96 includes a first end 98 that is coupled to an outlet 100 of the first muffler 92 and a second end 102 that is coupled to an inlet 104 of the second muffler 94. The inter-pipe 96 can be a single tube or can be comprised of multiple tube portions connected together to form a single tube between the first 92 and second 94 mufflers.

[0077] The first muffler 92 includes an inlet 106 that receives exhaust gas flow from an engine as indicated at 108. The second muffler 94 includes an outlet 110 that is coupled to a tailpipe 112. The passive valve assembly 12 is mounted within the inter-pipe 96 and is located at a position between the first 98 and second 102 ends at a location within a first 25% of the overall pipe length relative to one of first 98 and second 102 ends.

[0078] In one example, the passive valve assembly 12a is positioned within a first 25% of the overall pipe length relative to the first end 98 as indicated at 114. In another alternate example, the passive valve assembly 12b is positioned within a first 25% of the overall pipe length relative to the second end 102 as indicated at 116. In either example, by so locating the passive valve assembly 12a or 12b, the acoustic attenuation benefit of positioning the valve assembly 12a or 12b close to the velocity anti-node positions for the acoustic resonances existing within the inter-pipe 96 between the first 92 and second 94 mufflers is provided.

[0079] Another example of an exhaust system 120 is shown in Figure 5. This example is similar to that of Figure 4 but includes an additional foremost muffler 122 that is connected to an engine 124 upstream of the first muffler 92. The first 92 and second 94 mufflers in this configuration comprise additional or secondary mufflers that are used to provide additional noise attenuation. The foremost muffler 122 has an inlet 126 that is in fluid communication with the engine 124 and an outlet 128 that is in fluid communication with the inlet 106 of the first muffler 92. The passive valve assembly 12 is located in the inter-pipe 96 at a location within a first 25% of the overall pipe length relative to the first end 98 as indicated at 130.

[0080] As discussed above, the passive valve assembly 12 is advantageously positioned within a vehicle exhaust system at a certain positional relationship to other exhaust components to provide a significant acoustic advantage for overall noise attenuation. Figure 6 schematically shows another example configuration of a vehicle exhaust system 200 that includes at least one first resonator or muffler 202 and at least one second resonator or muffler 204. The first muffler 202 has an inlet 206 that receives exhaust gas flow from an engine as indicated at 208. The first muffler 202 includes an outlet 210 that directs exhaust gases to an inter-pipe 212.

[0081] The inter-pipe 212 fluidly connects the outlet 210 of the first muffler 202 to an inlet 214 of the second muffler 204. The second muffler 204 includes an outlet 216 that is fluidly connected to a tailpipe 218. The inter-pipe 212 can be a single tube or can be comprised of multiple tube portions connected together to form a single tube between the first 202 and second 204 mufflers. Similarly, the tailpipe 218 can be a single tube or can be comprised of multiple tube portions connected together to form a single flow gas exit from the exhaust system 200.

[0082] The inter-pipe 212 forms the sole exhaust gas flow path between the first 202 and second 204 mufflers. In other words, there is no by-pass flow option within the fluid connections between the first 202 and second 204 mufflers. As such, the inter-pipe 212 extends from a first end 220 to a second end 222 to define an overall pipe length referred to as a developed length of the pipe. The first 220 and second 222 ends need not be co-axial, thus the developed length of the pipe can be comprised of a single straight section of pipe or can be comprised of a combination of straight and curved sections of pipe having their lengths added together.

[0083] The passive valve assembly 12 is mounted external to the first 202 and second mufflers 204 and within the inter-pipe 212. The passive valve assembly 12 is positioned within the inter-pipe 212 between the first 220 and second 222 ends at a specified location in relation to the second muffler 204. This will be discussed in greater detail below.

[0084] Figure 7 shows a cross-sectional view of the second muffler 204. The second muffler 204 defines an internal cavity 224 that has the single inlet 214 and the single outlet 216. The inlet 214 and outlet 216 cooperate to define the sole internal flow path 226 within the second muffler 204. This internal flow path 226 occupies a specified portion of the internal cavity 224 leaving a remaining portion that is not occupied by the internal flow path 226. This remaining portion is packed with a high frequency absorption material 228. In one example a fiber-based material is used, however, any suitable material for attenuating high frequency noise can be used.

[0085] In the example shown, the sole internal flow path 226 is contained within a pipe body 230 that extends from the inlet 214 to the outlet 216, and the high frequency absorption material 228 completely fills the internal cavity 224 to completely surround the pipe body 230. This completely packed configuration is the most common configuration and is the most efficient configuration from an assembly and manufacturing perspective.

[0086] As shown in Figure 8, the passive valve assembly 12 is mounted within the inter-pipe 212 at a specified distance relative to the inlet 214 of the second muffler 204 as indicated at 232. The pipe body 230 is defined by a pipe diameter D. This pipe diameter D can vary depending upon the type of vehicle application and/or other exhaust system characteristics. The passive valve assembly 12 is positioned at a distance 232 that is at least four times the pipe diameter D that defines the internal flow path 226. By locating the passive valve assembly 12 in such a relation to the inlet 214 of the packed second muffler 204, absorption of flow noise is maximized due to distances involved in generation of flow noise from a geometric step change.

[0087] In another example shown in Figure 9, a pipe 250 extends from the inlet 214 to the outlet 216 to define a sole internal flow path 252. The pipe 250 includes a perforated section 254. The perforated section 254 is positioned within the internal cavity 224 and extends along a portion of an overall length of the pipe 250. As such, a length L of the perforated section 254 is less than the overall length of the pipe 250. The perforated section 254 at least partially extends about an outer circumference of the pipe 250, and in the example shown, extends entirely about the outer circumference of the pipe 250.

[0088] The high frequency absorption material 228 is positioned with the internal cavity 224 to contact at least a portion of the perforated section 254 to provide a packed configuration. In the example shown, the high frequency absorption material 228 is positioned to contact the entire length L of the perforated section 254. The high frequency absorption material 228 can comprise material that is packed around the pipe to provide this contact, or the high frequency absorption material 228 can comprise a mat that is wrapped around the perforated section 254.

[0089] In the example shown in Figure 9, the high frequency absorption material 228 also contacts the pipe 250 along non-perforated sections 256. Further, the pipe 250 can also include sections within the internal cavity 224 that are not in contact with high frequency absorption material 228. However, as described above, in each example the high frequency absorption material 228 does contact the entire length L of the perforated section 254 to provide the most effective attenuation of high frequency noise.

[0090] In the example shown in Figure 10, a tuning tube 260 is connected to the pipe 250 at one of the non-perforated sections 256 to provide additional noise attenuation. In this example, the tuning tube 260 is not at a location of the pipe 250 that is contact with high frequency absorption material 228. However, high frequency absorption material 228 could also be used on the pipe 250 at the tuning tube location. Further, the tuning tube 260 could also be used in the configuration shown in Figures 6-8.

[0091] For the configurations set forth in Figures 9 and 10, the passive valve assembly 12 is mounted within the inter-pipe 212 at a specified location relative to the inlet 214 of the second muffler 204 as described above in the examples of Figures 6-8. Also, the pipe body 230 shown in Figures 7 and 8 could include a perforated section in combination with a completely packed internal cavity.

[0092] The use of a packed high frequency muffler downstream of a throttling, spring-biased passive valve provides an effective configuration for attenuating noise. The passive valve assembly 12, which is effective for attenuating low frequency noises, cooperates with the packed muffler, which is effective for attenuating high frequency noise, to provide an exhaust system with significantly improved noise attenuation capability.

[0093] Figure 11 shows the exhaust pipe 10 and the passive valve assembly 12 in combination with a stop feature. The exhaust pipe 10 comprises a single pipe body 14 that defines the exhaust gas flow path 16. In one example, the pipe body 14 includes a curved outer surface 14a and a curved inner surface 14b that defines the exhaust gas flow path 16. In one example, the pipe body 14 has a circular cross-section.

[0094] The passive valve assembly 12 includes a valve body or vane 18 that blocks a portion of the exhaust gas flow path 16 when in the closed position. As discussed above, the vane 18 is pivoted toward the open position to minimize blockage of the exhaust gas flow path 16 in response to pressure exerted against the vane 18 by exhaust gases. The vane 18 comprises a body structure 300, such as a disc-shaped body for example, which includes a first portion 302 that is coupled to the shaft 20 with the connecting arm 22. The body structure 300 extends from the first portion 302 to a second portion that comprises a distal tip 304. As such, the tip 304 comprises a portion of the body structure 300 that is furthest from the axis of rotation A.

[0095] A stop 306 is supported by the pipe body 14 and is positioned within the exhaust gas flow path 16. The stop 306 defines the closed position for the vane 18. The tip 304 of the vane 18 engages the stop 306 when the spring 42 returns the vane 18 from the open position to the closed position.

[0096] In one example, as shown in Figures 11 and 12, the stop 306 comprises a ramped surface 308 that begins at the inner surface 14b at a position upstream from the vane 18 and extends outwardly away from the inner surface 14b and towards the vane 18. The ramped surface 308 then transitions into a stopper end surface 310 that extends back towards the inner surface 14b. The tip 304 of the vane 18 engages the stopper end surface 310 when in the closed position.

[0097] As shown in Figure 12, the ramped surface 308 and the stopper end surface 310 are angled relative to the inner surface 14b of the pipe body 14. The pipe body 14 defines a pipe centerline C, which is shown in Figure 12. As shown in Figure 13A, the ramped surface 308 is positioned at a ramp angle A that is within a range of 10 to 45 degrees relative to the pipe centerline C. Similarly, the stopper end surface 310 (Figure 13B) is positioned at an angle B relative to the pipe centerline C. In one example, the ramped surface 308 and the stopper end surface 310 are obliquely orientated relative to the inner surface 14b and relative to the pipe centerline C.

[0098] In one example, a pad 312 is supported on the stopper end surface 310 to provide a cushioned surface to engage the tip 304 of the vane 18. The pad 312 can be made from a mesh material or other similar material, for example, and can be attached to the stopper end surface 310 with any type of attachment method suitable for use within an exhaust component.

[0099] The stop 306 is positioned at the tip 304 of the vane 18 to minimize closing forces. By positioning these contact surfaces as far as possible from the axis of rotation A, contact forces are reduced, which in turn increases durability. Further, the upstream ramped surface 308 of the stop 306 reduces backpressure, turbulence, and the generation of additional flow noise.

[00100] In one example, the stop 306 is formed as one piece with the wall of the pipe body 14 as shown in Figure 14. A tool 314 is used to indent a portion 316 of the pipe body 14 itself to form the stop 306. The pad 312 can then be attached to the stopper end surface 310 as discussed above.

[00101] In another example shown in Figure 15, the stop 306 comprises a separate body 320 that is welded to the inner surface 14b of the pipe body 14 as indicated at 322. The pad 312 can then be attached as described above. The pad 312 and the separate body 320 can be made from common materials, or the pad 312 can be made from a different material that is attached to the stop 306.

[00102] In another example shown in Figures 16A-16D, the stop 306 comprises a duckbill portion 330 that is positioned upstream of the stopper end surface 310. The duckbill portion 330 has a radius of curvature R that is contoured to match the inner surface 14b of the pipe body 14. The duckbill portion 330 is spot welded, as indicated at 332, to the pipe body 14. The duckbill portion 330 transitions into the ramped surface 308, which in this example comprises a curved surface. The ramped surface 308 terminates at the stopper end surface 310, which extends back toward the inner surface 14b of the pipe body 14 in a direction away from a centerline of the pipe body 14. In the example shown, the duckbill portion 330 is formed as one-piece with the ramped surface 308 and the stopper end surface 310. The pad 312 can be attached to the stopper end surface 310 as described above.

[00103] The subject passive valve assembly 12 with the stop 306 and pad 312 can effectively and efficiently return a vane 18 to a consistent, repeatable closed position without generating additional unwanted noise. Additionally, the pad 312 is positioned adjacent the tip 304 of the vane 18 to minimize closing forces and to improve durability of the passive valve assembly. Further, the orientation and position of the ramped surface 308 of the stop 306 also reduces noise in addition to reducing backpressure and turbulence.

[00104] Figure 17 shows the shaft 20, spring 42, and bushings 28, 30 in greater detail. The first bushing 28 is positioned generally at the first shaft end 32 and comprises a sealed interface for the first shaft end 32. The shaft 20 includes a shaft body 400 that is defined by a first diameter D1. Near the first shaft end 32 is the first collar 36, which is defined by a second diameter D2 that is greater than the first diameter D1. The first bushing 28 includes a first bore 402 that receives the first shaft end 32. The first collar 36 abuts directly against an end face 404 of the first bushing 28 such that exhaust gas cannot leak out of the first bushing 28 along a path between the shaft 20 and first bushing 28.

[00105] The second bushing 30 includes a second bore 406 through which the shaft body 400 extends to the second shaft end 40. The shaft 20 includes the second collar 38, which is defined by a third diameter D3. The third diameter D3 is greater than the first diameter D1. The second D2 and third D3 diameters can be the same or different from each other. The second collar 38 is located axially inboard of the second bushing 30.

[00106] The shaft 20 extends through the second bore 406 to an axially outboard position relative to the second bushing 30. The spring 42 is coupled to the second shaft end 40 with the spring retainer 44. As described above, the spring retainer 44 includes the first retainer piece 46 that is fixed to the housing 26 and the second retainer piece 48 that is fixed to the second shaft end 40. One spring end 50 is associated with housing 26 via the first retainer piece 46 and a second spring end 408 (Figure 18) is associated with the shaft 20 via the second retainer piece 48. Advantageously, the spring 42 is located external to, i.e. outside of, the pipe body 14. As such, the spring 42 operates in a much cooler environment instead of being subjected directly to the high temperature exhaust gases as in prior designs.

[00107] In one example, the spring 42 comprises a coil spring that is configured to be compressed both in an axial direction along axis A and in a torsional direction about the axis A during installation. Torsional loading creates a preload force that biases the shaft 20 and the vane 18 toward the closed position. As gas flow increases, this torsional force is overcome to move the vane 18 toward the open position. The axial force serves to positively seat and seal the second collar 38 against an end face 410 of the second bushing 30. This prevents any exhaust gas from leaking out of the second bushing 30 by sealing off a passage between an outer surface of the shaft 20 and a bore surface of the second bushing 30. Thus, a single spring is used to provide both axial and torsional loading, resulting in a configuration that can both hold the passive valve assembly 12 in a desired operational position as well as preventing exhaust gas leakage.

[00108] The spring 42 is shown in greater detail in Figure 18. The spring 42 is a coil spring formed from wire having a diameter Dw. Prior to installation, the spring 42 is defined by a free length condition FL where a first pitch dimension P1 is greater than the diameter Dw. This relationship results in spacing between adjacent coils by a gap 412. The gaps 412 between adjacent coils enable the spring 42 to be compressed in the axial direction as well as in the torsional direction during installation. This results in a second pitch dimension P2 (Figure 1) that is less than the first pitch dimension P1.

[00109] In one example configuration, the spring 42 has a wire diameter Dw that is approximately 1.8 mm, and a first pitch dimension P1 that is greater than 2 mm. The spring 42 also has an overall outer diameter of 17 mm and a free length FL of approximately 30 mm. When compressed for installation this free length FL is reduced by approximately 5 mm. It should be understood that this is just one example configuration and that other configurations could be used as needed to provide desired characteristics.

[00110] By utilizing a single spring that can act both in torsion and axially, the shaft can be loaded against the bushing, which will minimize exhaust gas leakage between the shaft and the bushing. Further, this configuration can be used to minimize build up variations because the shaft will always be positively located against the bushing.

[00111] The passive valve assembly 12 also provides a significant amount of coverage of the exhaust gas flow path 16 when in the closed position as compared to prior valves, which have 50% or less coverage when closed. In the example shown in Figures 19-20, the passive valve assembly 12 is positioned in an exhaust tube 420 having a first tube end 422 that is connected to a first exhaust component 424 and a second tube end 426 that is connected to a second exhaust component 428. The first 424 and second 428 exhaust components can comprise components such as a muffler, tailpipe, etc.

[00112] In one example, shown in Figure 21, the first exhaust component 424 comprises a muffler 430 and the second exhaust component 428 comprises a tailpipe 432. The exhaust tube 420 is connected to an outlet 434 of the muffler 430 and an inlet to the tailpipe 432. In another example, both the first 424 and second 428 components comprise mufflers (schematically shown in Figure 19) with the exhaust tube 420 being connected to an outlet from one muffler and to an inlet from another muffler.

[00113] In either configuration, the exhaust tube 420 has an internal bore or opening 436 that fluidly connects the first 424 and second 428 exhaust components and defines the exhaust gas flow path 16. The exhaust gas flow path 16 is sole flow path between the first 424 and second 428 exhaust components. In other words, there is no by-pass flow path associated with the exhaust tube 420, and the only path through which exhaust gases can flow is exhaust gas flow path 16 within the exhaust tube 420

[00114] As shown in Figure 19, the vane 18 is pivotable within the opening 436 from a substantially closed position (solid line) to a substantially open position (dashed line). The vane 18 is biased by the spring 42 (shown schematically) toward the closed position as schematically indicated at 440. When exhaust gas pressure, indicated by arrow 442, exceeds a certain level, the spring force is overcome and the vane 18 is moved toward the open position.

[00115] The opening 436 is defined by a cross-sectional area. When the vane 18 is in the closed position, this cross-sectional area is covered, i.e. closed off, by approximately 80-97%. In one example, the cross-sectional area is covered within a range of 87.5-92.5%. Thus, only a very small part of the cross-sectional area is left open for exhaust gas flow when the vane 18 is in the closed position (see Figure 20). This high percentage of coverage, in combination with a non-bypass configuration, provides a very effective way to attenuate low frequency noise.

[00116] Figures 22-23 show an example an offset passive valve configuration. As discussed above, the pipe body 14 includes a curved outer surface 14a and a curved inner surface 14b that defines the exhaust gas flow path 16 (Figure 1). The vane 18 comprises a disc-shaped body 500 that is generally flat, and which has a significantly greater width W (Figure 1) or diameter than a thickness t (Figure 22) of the disc-shaped body 60. The vane 18 defines a plane (a vane center plane) P (Figure 22) that extends across the width W of the disc-shaped body 500. It should be noted that the thickness t of the disc-shaped body 500 is exaggerated in Figure 22 to clearly show the plane P.

[00117] As shown in Figure 22, the plane P is offset from the axis of rotation A by a distance D. This distance D remains generally constant as the vane 18 is pivoted between the open and closed positions, and as such, the plane P and the axis of rotation A have a non-intersecting relationship. By offsetting the plane P from the vane 18, the vane 18 can be pivoted to a fully open position as shown in Figure 23 without interfering with the curved inner surface 14b of a wall of the pipe body 14.

[00118] As shown in Figure 23, the exhaust gas flow path 16 extends in a first direction, indicated by arrow 502, and the axis of rotation A extends in a second direction that is different than the first direction. The plane P is offset from the axis of rotation A in the first direction. In the example shown, the first and second directions are perpendicular to each other and the plane P is positioned in the exhaust gas flow path 16 at a location upstream from the axis of rotation A.

[00119] The connecting arm 22 includes a first portion 504 that is coupled to the shaft 20 and a second portion 506 that is coupled to the vane 18. In one example, the connecting arm 22 is welded to the shaft 20 and vane 18 at the first 504 and second 506 portions, respectively. The connecting arm 22 extends transversely to both the plane P and the axis of rotation A. In one example, the connecting arm 22 is perpendicular to the axis of rotation A and the plane P.

[00120] As shown in Figure 23, the pipe body 14 extends longitudinally, i.e. along a length, to define a center axis C that coincides with a center of the exhaust gas flow path 16. In the example shown, the plane P of the vane 18 is generally parallel to, and offset from, the center axis C when the vane 18 is in the open position to provide a fully open, maximum flow, position. The offset relationship between the vane 18 and the shaft 20 provided by the transversely extending connecting arm 22 allows minimal blockage when open, i.e. maximizes the opening angle, which results in minimal backpressure.

[00121] Although a preferred embodiment of this invention has been disclosed, a worker of ordinary skill in this art would recognize that certain modifications would come within the scope of this invention. For that reason, the following claims should be studied to determine the true scope and content of this invention.

CLAIMS

What is claimed is:

1. A vehicle exhaust system comprising:

at least one muffler having an inlet and an outlet, said outlet comprising a first pipe body having a first end located at said at least one muffler and extending to a second end to define a first overall pipe length, said first pipe body defining a sole exhaust flow path between said first and said second ends of said first pipe body, and said inlet comprising a second pipe body having a first end located at said at least one muffler and extending to a second end to define a second overall pipe length, said second pipe body defining a sole exhaust flow path between said first and second ends of said second pipe body; and

a passive valve assembly mounted outside of said at least one muffler and within one of said first and said second pipe bodies, said passive valve assembly being positioned at a location within a first 25% of a respective one of said first and said second overall pipe lengths relative to an associated one of said inlet and said outlet of said at least one muffler.

2. The vehicle exhaust system according to claim 1 wherein said at least one muffler comprises at least first and second mufflers with said first pipe body comprising an inter-pipe that connects an output from said first muffler to an inlet to said second muffler, said inter-pipe comprising the sole exhaust flow path between said first and said second mufflers, and wherein said passive valve assembly is mounted within said inter-pipe at a location within a first 25% of said first overall pipe length relative to said outlet of said first muffler.

3. The vehicle exhaust system according to claim 2 including a third muffler positioned upstream of said first muffler with said second muffler being positioned downstream of said first muffler, and including a tail pipe connected to an outlet from said second muffler.

4. The vehicle exhaust system according to claim 2 wherein said passive valve assembly comprises the only valve assembly positioned between said first and said second mufflers.

5. The vehicle exhaust system according to claim 1 wherein said first pipe body comprises a tailpipe and wherein said passive valve assembly is mounted within said tailpipe at a location within a first 25% of said first overall pipe length relative to said outlet of said at least one muffler.

6. The vehicle exhaust system according to claim 1 wherein said passive valve assembly comprises a vane supported on a shaft for pivotable movement within said one of said first and said second pipe bodies between an open position and a closed position, and a spring that biases said vane toward said closed position, said vane being pivotal from said closed position towards said open position in response to an exhaust gas flow that exceeds a biasing force of said spring.

7. The vehicle exhaust system according to claim 1 wherein said second pipe body comprises an input pipe that defines a sole flow path between said at least one muffler and an upstream exhaust component, and wherein said passive valve assembly is mounted within said input pipe at a location within a first 25% of said second overall pipe length relative to said inlet of said at least one muffler

8. A vehicle exhaust system comprising:

a first exhaust component having a first inlet and a first outlet;

a second exhaust component positioned downstream of said first exhaust component, wherein said second exhaust component defines an internal cavity with a second inlet and a second outlet, said internal cavity being at least partially packed with a high frequency absorption material;

an inter-pipe connecting said first outlet with said second inlet; and

a passive valve mounted within said inter-pipe.

9. The vehicle exhaust system according to claim 8 wherein said inter-pipe comprises the sole exhaust gas flow path between said first outlet and said second inlet.

10. The vehicle exhaust system according to claim 8 wherein said first and said second exhaust components comprise first and second resonators.

11. The vehicle exhaust system according to claim 1 wherein said second inlet and said second outlet cooperate to define a flow path through said second exhaust component, and wherein said flow path is defined by a pipe diameter and wherein said passive valve is mounted within the inter-pipe at a distance from said second inlet of said second exhaust component that is at least four times said pipe diameter.

12. The vehicle exhaust system according to claim 11 wherein said flow path comprises a sole flow path through said second exhaust component.

13. The vehicle exhaust system according to claim 8 including a pipe extending from said second inlet to said second outlet to define a sole flow path through said second exhaust component, said pipe including a perforated section positioned within said internal cavity, and wherein said high frequency absorption material is positioned to contact at least a portion of said perforated section to provide a packed second exhaust component.

14. The vehicle exhaust system according to claim 13 including at least one tuning tube positioned within said internal cavity and in communication with said pipe.

15. A vehicle exhaust system comprising:

a first exhaust component having a first inlet and a first outlet;

a second exhaust component defining an internal cavity having a second inlet and a second outlet that cooperate to define an internal flow path through said second exhaust component,;

a pipe extending from said second inlet to said second outlet to define said internal flow path as a sole flow path through said second exhaust component;

high frequency absorption material positioned within said internal cavity to contact at least a portion of said pipe to provide a packed second exhaust component;

an inter-pipe connecting said first outlet with said second inlet; and

a passive valve mounted within said inter-pipe.

16. The vehicle exhaust system according to claim 15 wherein said passive valve comprises a vane supported on a shaft for pivotable movement within said inter-pipe between an open position and a closed position, and a spring that biases said vane toward said closed position, said vane being pivotal from said closed position towards said open position in response to an exhaust gas flow that exceeds a biasing force of said spring.

17. A passive valve assembly for a vehicle exhaust system comprising:

an exhaust component defining an exhaust gas flow path;

a vane supported by a shaft and positioned within the exhaust gas flow path, said vane being pivotable between an open position and a closed position; and

a stop positioned within said exhaust gas flow path to define the closed position for said vane.

18. The passive valve assembly according to claim 17 wherein said vane comprises a disc-shaped body having a first portion that is coupled to said shaft, said disc-shaped body extending from said first portion to a tip, and wherein said stop is positioned within said exhaust gas flow path to engage said tip.

19. The passive valve assembly according to claim 17 wherein said stop includes a padded surface that engages said vane when in said closed position.

20. The passive valve assembly according to claim 17 wherein said stop comprises a ramped surface that extends from an inner wall surface of said exhaust component toward said vane and a stopper end surface that extends from said ramped surface back toward said inner wall surface, said vane abutting against said stopper end surface when in said closed position.

21. The passive valve assembly according to claim 20 wherein said ramped surface is obliquely orientated relative to a centerline of said exhaust component.

22. The passive valve assembly according to claim 20 wherein said stopper end face surface is obliquely orientated relative to a centerline of said exhaust component.

23. The passive valve assembly according to claim 20 wherein said ramped surface begins at a position that is upstream from said vane.

24. The passive valve assembly according to claim 20 wherein said exhaust component defines a centerline that coincides with a center of the exhaust gas flow path, and wherein said ramped surface is orientated at an angle within a range of 10 to 45 degrees relative to said centerline.

25. The passive valve assembly according to 17 including a resilient member that biases said vane toward said closed position, said vane being pivoted from said closed position towards said open position in response to an exhaust gas flow that exceeds a biasing force of said resilient member, and wherein said resilient member moves said vane into abutting engagement with said stop when the exhaust gas flow is less than said biasing force of said resilient member.

26. The passive valve assembly according to 25 wherein said shaft defines an axis of rotation that is positioned adjacent one edge of said vane, and wherein said stop is positioned at an opposite edge of said vane from said axis of rotation.

27. A passive valve assembly for a vehicle exhaust system comprising:

an exhaust component comprising a wall with an external surface and an internal surface that defines an exhaust gas flow path;

a housing attached to said external surface;

a shaft supported within said housing by at least one bushing, said shaft defining an axis of rotation;

a vane supported by said shaft and positioned within the exhaust gas flow path, said vane being pivotable between an open position and a closed position, and wherein said vane comprises a body structure having a first portion coupled to said shaft with said body structure extending from said first portion to a tip;

a resilient member that biases said vane toward said closed position, said vane only being pivoted from said closed position towards said open position in response to an exhaust gas flow that exceeds a biasing force of said resilient member; and

a stop positioned within said exhaust gas flow path to define said closed position for said vane, said tip of said body structure contacting said stop when in said closed position.

28. The passive valve assembly according to claim 27 wherein said stop comprises a ramped surface that extends from said internal surface of said exhaust component toward said vane and a stopper end surface that extends from said ramped surface back toward said internal surface, said vane abutting against said stopper end surface when in said closed position

29. A passive valve assembly for an exhaust system comprising:

an exhaust tube having a bore defining an exhaust flow path having a cross-sectional area, said exhaust tube having one end to be connected to a first exhaust component and a second end to be connected to a second exhaust component, such that said exhaust tube forms a sole exhaust path extending between the first and the second exhaust components;

a vane mounted within said bore and being moveable between an open position and a closed position, said vane providing 80% to 97% coverage of said cross-sectional area when in said closed position; and

a resilient member that biases said vane toward said closed position.

30. The passive valve assembly according to claim 29 wherein said vane provides 87.5% to 92.5% coverage of said cross-sectional area when in said closed position

31. The passive valve assembly according to claim 29 wherein said vane comprises the only valve assembly positioned between the first and the second exhaust components.

32. The passive valve assembly according to claim 29 including a shaft mounted to said vane, said shaft being pivotally supported by at least one bushing, and wherein said resilient member comprises a spring that is supported on said shaft, and wherein said exhaust tube includes a slot that receives a housing, said housing including a central bore that receives said at least one bushing and said shaft, and wherein said shaft extends between first and second shaft ends with said spring being supported on one of said first and said second shaft ends outside of said exhaust tube.

33. The passive valve assembly according to claim 29 wherein said vane is movable from said closed position toward said open position solely in response to exhaust gas flow.

34. The passive valve assembly according to claim 29 wherein one of said first and said second exhaust components comprises a muffler and the other of said first and said second exhaust components comprises one of a tailpipe and another muffler.

35. A passive valve assembly for a vehicle exhaust system comprising:

an exhaust component having a wall with an inner surface defining an exhaust gas flow path;

a vane positioned within the exhaust gas flow path, said vane being pivotable between an open position and a closed position, and said vane defining a plane that extends across a width of said vane; and

a shaft supported by said wall and defining an axis of rotation, said shaft pivoting said vane between said open and said closed positions, and wherein said plane of said vane is offset from said axis of rotation.

36. The passive valve assembly according to claim 35 wherein said plane does not intersect said axis of rotation.

37. The passive valve assembly according to claim 36 wherein said plane is spaced apart from said axis of rotation by a generally constant distance as said vane pivots between said open and said closed positions.

38. The passive valve assembly according to claim 35 wherein said exhaust gas flow path extends in a first direction and said axis of rotation extends in a second direction that is different from said first direction, and wherein said plane is offset from said axis of rotation in said first direction.

39. The passive valve assembly according to claim 38 wherein said first direction is perpendicular to said second direction.

40. The passive valve assembly according to claim 38 wherein said vane comprises a generally flat disc-shaped body having a greater width than thickness and wherein said plane is defined across the width of said generally flat disc-shaped body.

41. The passive valve assembly according to 35 including a resilient member that biases said vane toward said closed position, said vane being pivoted from said closed position

towards said open position in response to an exhaust gas flow that exceeds a biasing force of said resilient member.

42. The passive valve assembly according to claim 35 wherein said exhaust component comprises a longitudinally extending pipe defining a center axis and wherein said plane of said vane is offset from, and generally parallel to, said center axis when in a fully open, maximum flow position.

43. The passive valve assembly according to claim 35 wherein said exhaust component comprises a circular pipe defining a center axis that coincides with a center of the exhaust gas flow path, and wherein said plane of said vane and said center axis have a non-intersecting relationship when in a maximum flow position.

44. A passive valve assembly for a vehicle exhaust system comprising:

an exhaust pipe having a curved wall with an inner surface defining an exhaust gas flow path;

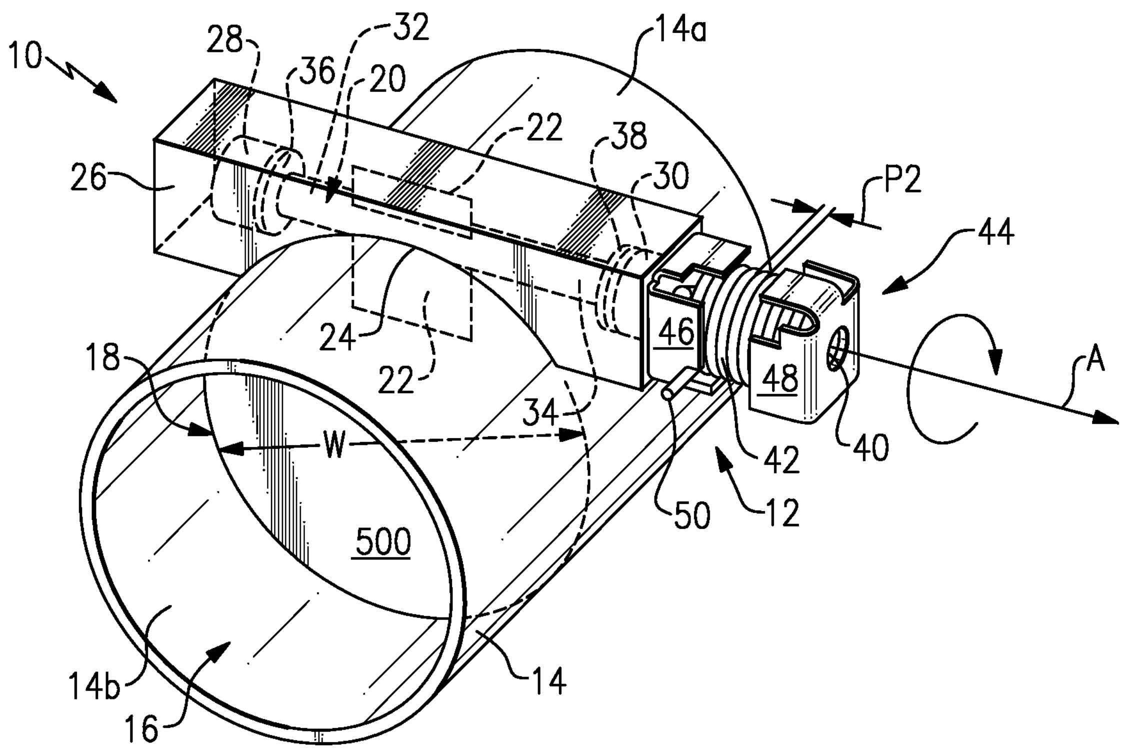
a vane positioned within the exhaust gas flow path, said vane being pivotable between an open position and a closed position, and said vane comprising a disc-shaped body having a greater width than thickness, with said vane defining a plane that extends across said width of said disc-shaped body; and

a shaft coupled to said vane and defining an axis of rotation, said shaft pivoting said vane between said open and said closed positions, and wherein said plane of said vane is offset from said axis of rotation.

45. The passive valve assembly according to claim 44 wherein said plane has a non-intersecting relationship to said axis of rotation.

46. The passive valve assembly according to claim 44 wherein said axis of rotation remains spaced apart from said plane by a generally constant distance as said vane moves between said open and said closed positions.

47. The passive valve assembly according to claim 44 wherein said plane is positioned in the exhaust gas flow path at a position that is upstream relative to said axis of rotation.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38
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26
P2
44
24
46
22
48
A
18
34
40
42
W
500
50
12
14b
14
16

FIG.1

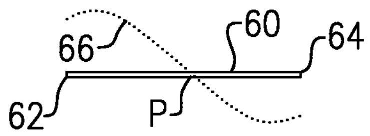


FIG.2

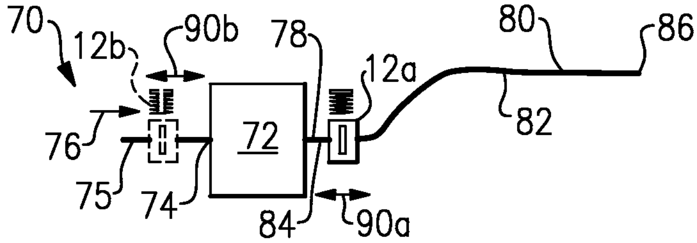


FIG.3

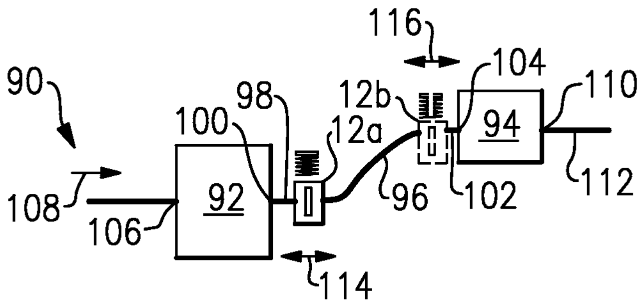


FIG.4

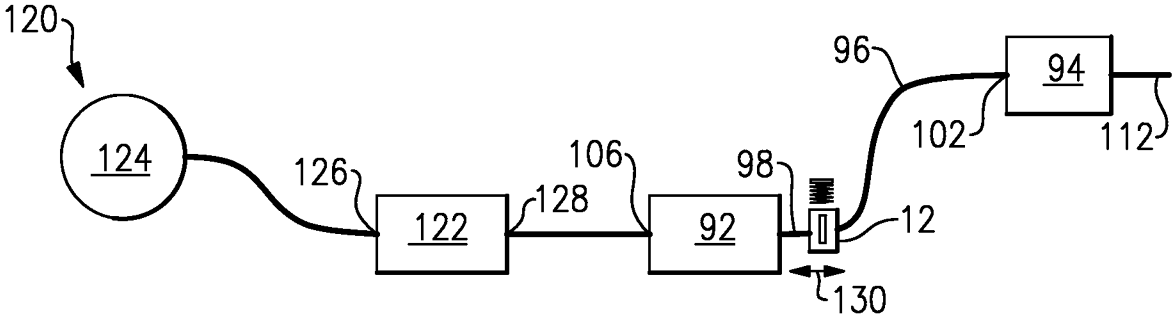


FIG.5

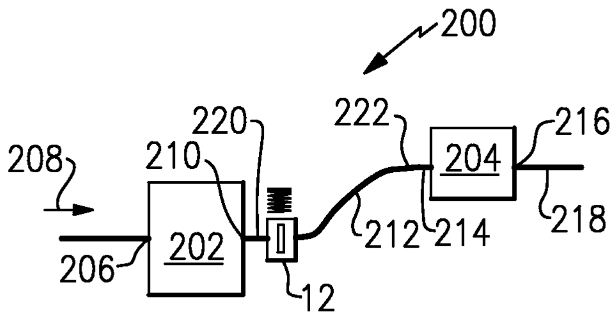


FIG.6

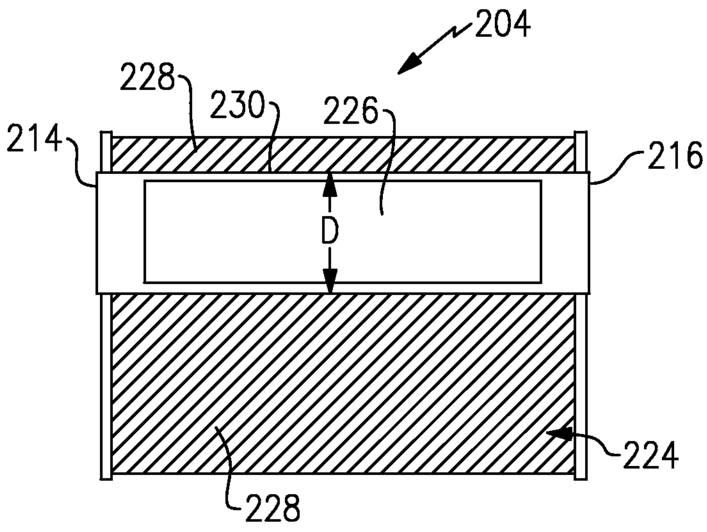


FIG.7

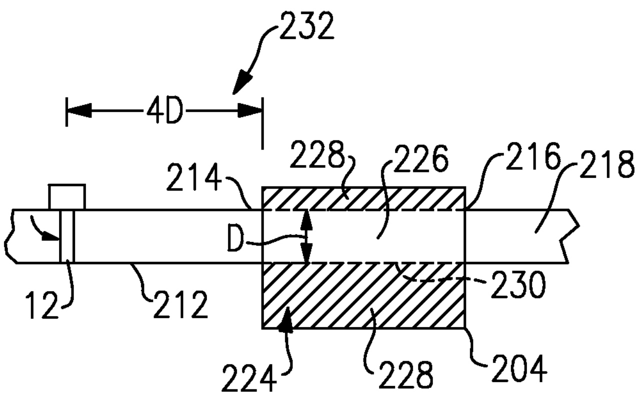


FIG.8

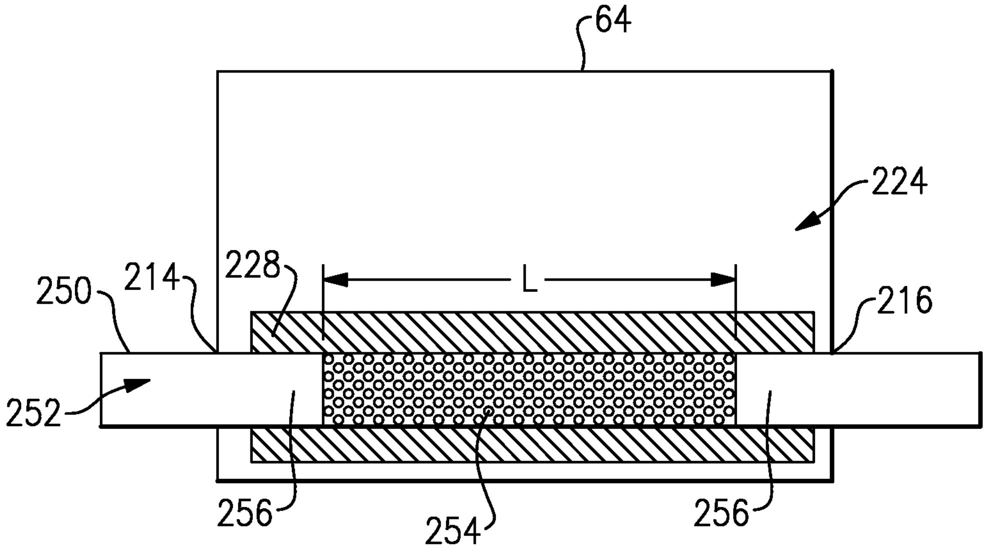

64
224
228
L
250
214
216
252
256
254
256

FIG.9

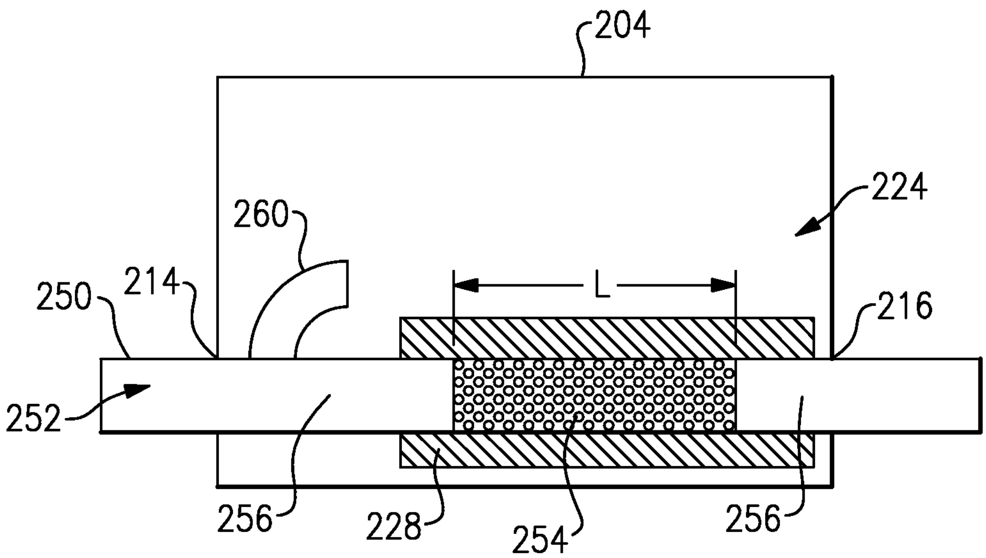
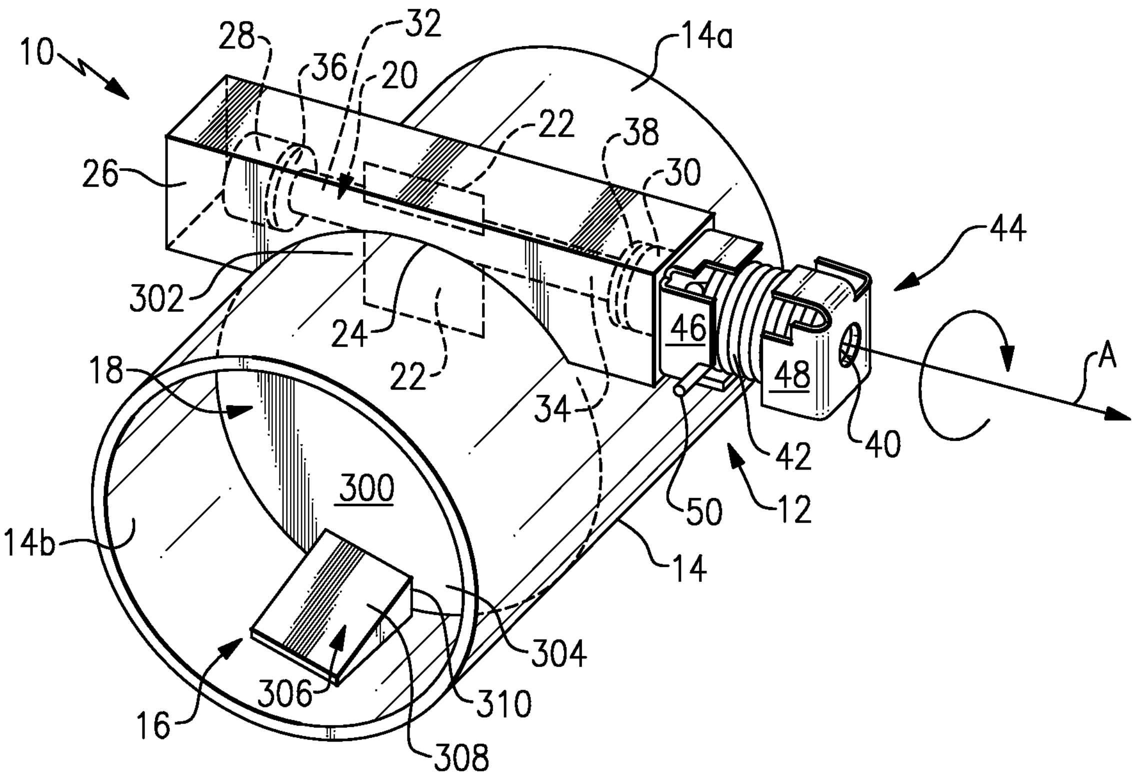

204
224
260
L
250
214
216
252
256
228
254
256

FIG.10


10
28
32
36
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14a
22
38
30
26
44
302
24
46
48
A
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18
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42
40
300
50
12
14b
14
304
306
310
16
308

FIG.11

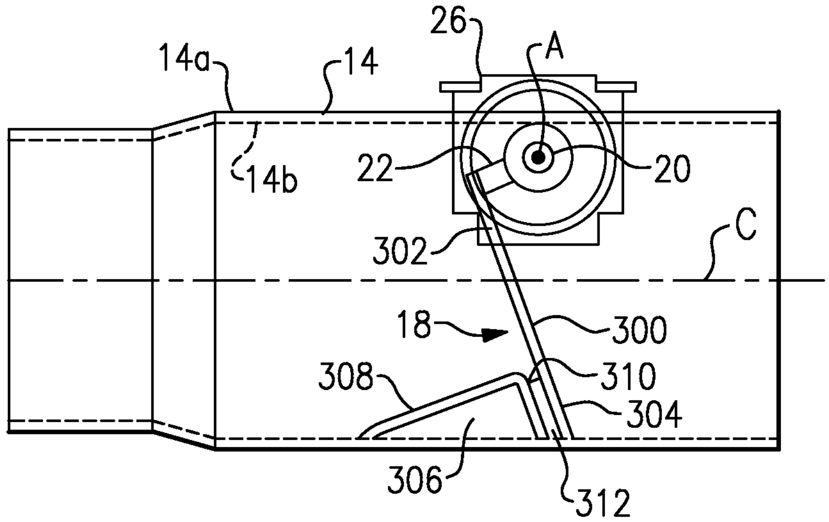


FIG.12

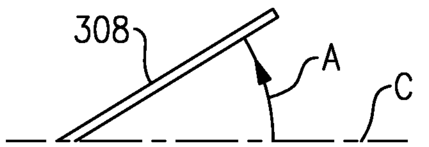


FIG.13A

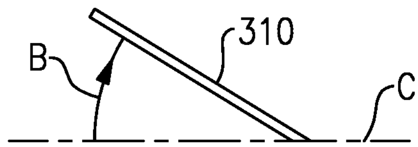


FIG.13B

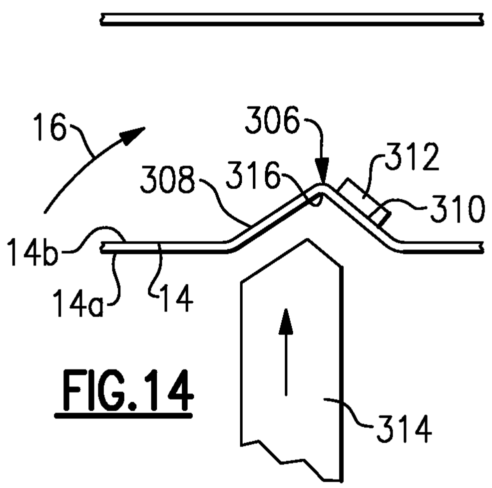


FIG.14

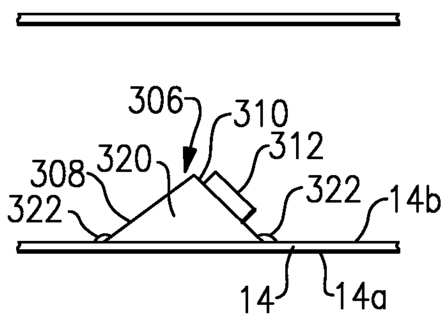


FIG.15

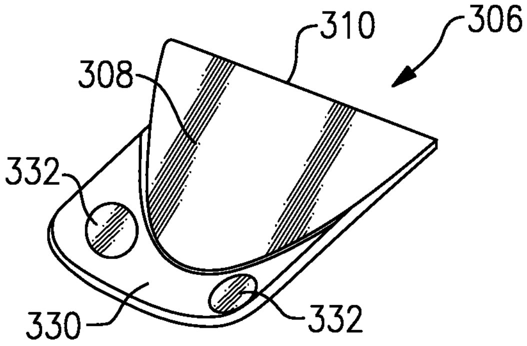


FIG.16A

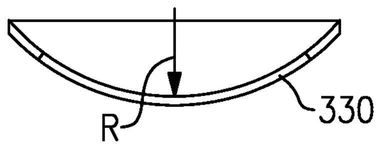


FIG.16B

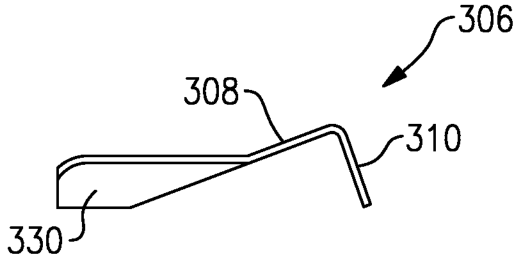


FIG.16C

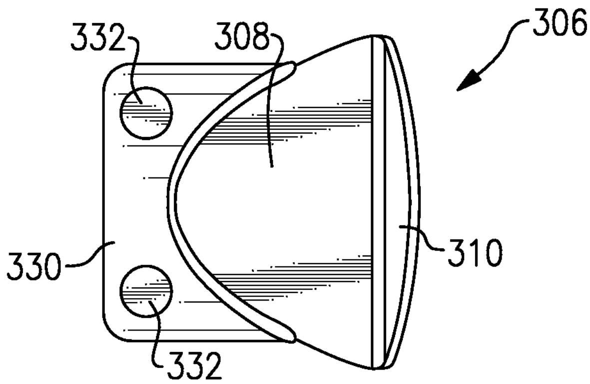
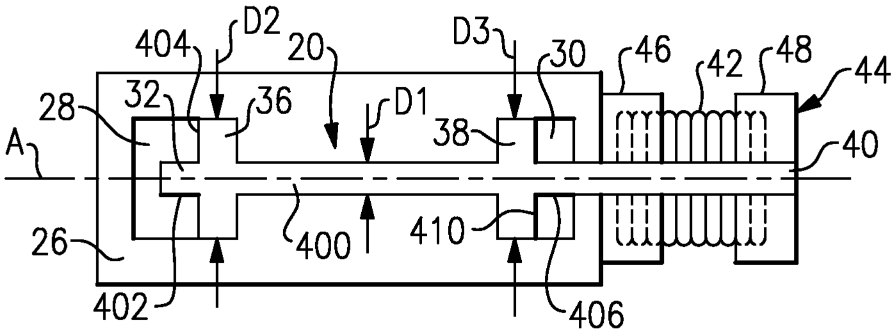
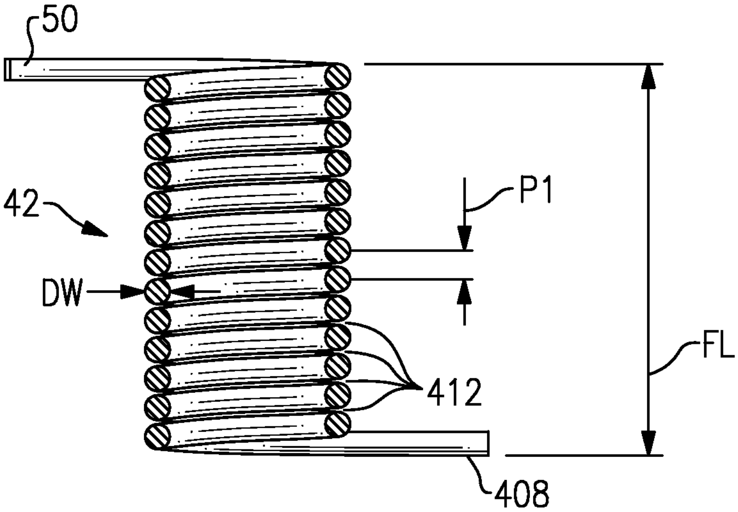


FIG.16D



404
D2
20
D3
30
46
42
48
44
28
32
36
D1
38
A
40
26
400
410
402
406

FIG.17



50
42
P1
DW
FL
412
408

FIG.18

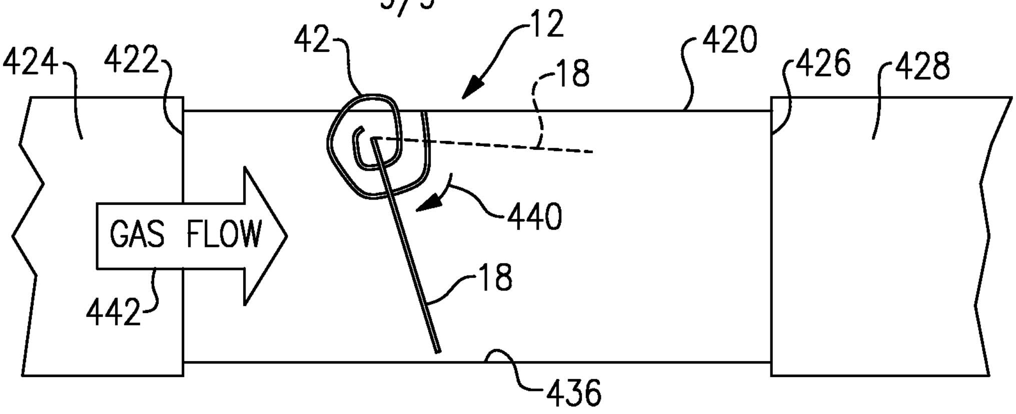


FIG.19

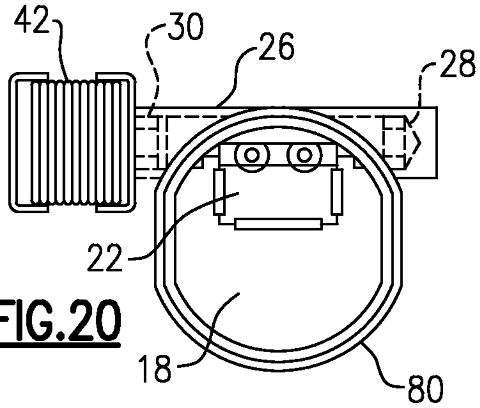


FIG.20

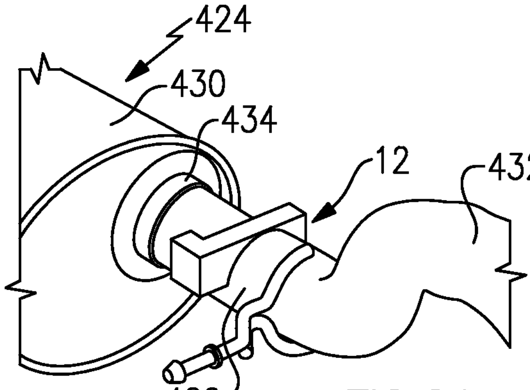


FIG.21

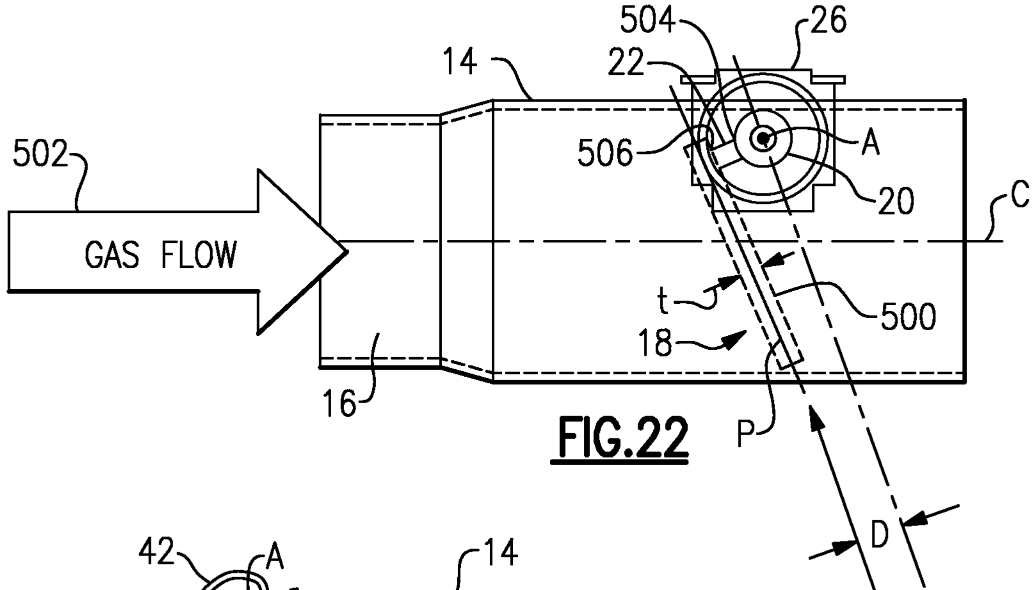


FIG.22

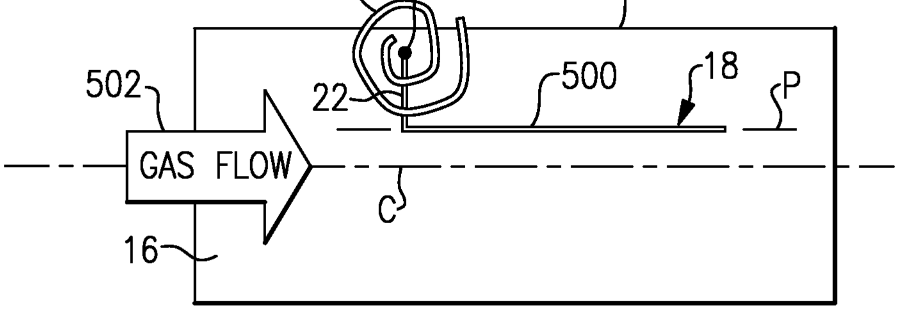


FIG.23