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(71) Applicant: **BORGWARNER INC.** [US/US]; Patent Department, 3850 Hamlin Road, Auburn Hills, Michigan 48326 (US).

(72) Inventors: **GRABOWSKA, David George**; 16 Deer Run Dr., Asheville, North Carolina 28803 (US). **WATSON, John Paul**; 11 Bramblewood Road, Arden, North Carolina 28704 (US). **HURWITZ, Benjamin Philip**; 204 Weston Way, Asheville, North Carolina 28803 (US).

(74) Agent: **MILLER, Thomas** et al.; Miller, Matthias & Hull LLP, One North Franklin Street Suite 2350, Chicago, Illinois 60606 (US).

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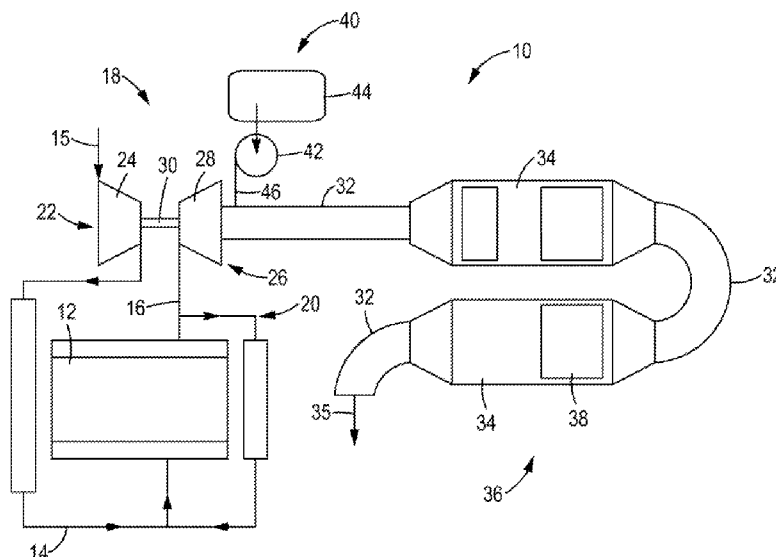


FIG. 1

(57) Abstract: A turbine diffuser configured for use in a turbocharger is disclosed. The turbine diffuser may comprise a diffuser wall defining the diffuser, and a diesel exhaust fluid (DEF) dosing structure disposed in the diffuser and configured to dose DEF into exhaust gas flowing through the diffuser. The DEF dosing structure may be supported in the diffuser by at least two structures affixed to the diffuser wall.



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- *as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))*
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TURBOCHARGER TURBINE DIFFUSER WITH DIESEL EXHAUST FLUID DOSING STRUCTURE

TECHNICAL FIELD

5 **[0001]** The present disclosure generally relates to turbochargers and, more specifically, to turbocharger turbine diffusers having a diesel exhaust fluid (DEF) dosing structure for delivering DEF into the exhaust gas stream.

BACKGROUND

10 **[0002]** Vehicle engine systems may include an internal combustion engine that combusts a mixture of fuel and air to power the engine. The combusted fuel and air is referred to as exhaust gas, which is released to the atmosphere through an exhaust system of the vehicle. The exhaust gas may contain pollutants (e.g., nitrogen oxides (NO_x), carbon monoxide (CO), particulate matter, hydrocarbons, etc.), which may be reduced prior to release of the exhaust gas to the atmosphere. Various emission control strategies have been employed to reduce the level of pollutants released into the atmosphere through the exhaust pipe. Many diesel engine systems, for example, include an aftertreatment system in the exhaust pipe to remove or reduce the level pollutants in the exhaust gas stream. One such aftertreatment system is a selective catalytic reduction (SCR) aftertreatment system in which a catalyst is used to reduce NO_x to nitrogen in the presence of a reducing agent, such as ammonia. In many SCR

15 aftertreatment systems, the reducing agent is supplied into the exhaust stream as aqueous urea, also referred to as diesel exhaust fluid (DEF), which converts to ammonia through thermal decomposition. Thorough mixing and evaporation of the DEF in the exhaust gas may increase the efficacy of the SCR aftertreatment system.

20 **[0003]** Thus, there is a need for improved strategies for mixing and uniformly distributing DEF in the exhaust gas in vehicle engine systems having an SCR aftertreatment system.

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SUMMARY

[0004] In accordance with one aspect of the present disclosure, a turbine diffuser configured for use in a turbocharger is disclosed. The turbine diffuser may comprise a diffuser wall defining the diffuser, and a diesel exhaust fluid (DEF) dosing structure disposed in the diffuser and configured to dose DEF into exhaust gas flowing through the diffuser. The DEF dosing structure may be supported in the diffuser by at least two structures affixed to the diffuser wall.

[0005] In accordance with another aspect of the present disclosure, a turbocharger for an engine system having an exhaust pipe with a selective catalytic reduction (SCR) aftertreatment system is disclosed. The turbocharger may comprise a compressor section and a turbine section rotatably coupled to the compressor section via a shaft. The turbine section may include a turbine wheel having a nose and a plurality of blades, and a turbine diffuser downstream of the turbine wheel and defined by a diffuser wall. The turbocharger may further comprise a diesel exhaust fluid (DEF) dosing structure disposed in the turbine diffuser downstream of the turbine wheel and configured to dose DEF into exhaust gas flowing through the diffuser. The DEF dosing structure may be supported in the diffuser by at least two structures affixed to the diffuser wall.

[0006] In accordance with another aspect of the present disclosure, a method for dosing diesel exhaust fluid (DEF) into an exhaust gas of a vehicle engine system is disclosed. The vehicle engine system may have a turbocharger and a selective catalytic reduction (SCR) aftertreatment system. The turbocharger may include a turbine wheel and a turbine diffuser downstream of the turbine wheel. The turbine diffuser may be defined by a diffuser wall. The method may comprise delivering the DEF through a strut of a diesel exhaust fluid (DEF) dosing structure positioned in the turbine diffuser. The strut may be affixed to the diffuser wall of the turbine diffuser. The method may further comprise dosing the DEF into the

exhaust gas flowing through the turbine diffuser through one or more dosing apertures of the DEF dosing structure, allowing the DEF to disperse into the exhaust gas, and supplying a mixture of the DEF and the exhaust gas to the SCR aftertreatment system.

[0007] These and other aspects and features of the present disclosure will be more readily understood when read in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] FIG. 1 is a schematic diagram of a vehicle engine system having a turbocharger with a diesel exhaust fluid (DEF) dosing system and a selective catalytic reduction (SCR) aftertreatment system.

[0009] FIG. 2 is a cross-sectional view through a turbine section of the turbocharger of FIG. 1.

[0010] FIG. 3 is a cross-sectional view through the turbine section of the turbocharger of FIG. 2 above a centerline of the turbocharger, illustrating a DEF dosing structure and a dosing cup in a turbine diffuser of the turbocharger, constructed in accordance with the present disclosure.

[0011] FIG. 4 is a perspective view of a turbine wheel and the dosing cup of FIG. 3 shown in isolation, constructed in accordance with the present disclosure.

[0012] FIG. 5 is a perspective view of the turbine diffuser and the DEF dosing structure of FIG. 3 shown in isolation, constructed in accordance with the present disclosure.

[0013] FIG. 6 is a cross-sectional view through the section 6-6 of FIG. 5, illustrating a dosing strut and a center body of the DEF dosing structure in isolation, constructed in accordance with the present disclosure.

[0014] FIG. 7 is cross-sectional view similar to FIG. 6 but having a delivery pipe extending through the dosing strut and the center body, constructed in accordance with the present disclosure.

[0015] FIG. 8 is a cross-sectional view through the section 8-8 of FIG. 6, illustrating the airfoil shape of the dosing strut, constructed in accordance with the present disclosure.

[0016] FIG. 9 is a perspective view of the turbine diffuser similar to FIG. 5 but with the dosing strut and the center body of the DEF dosing structure having a different configuration,
5 constructed in accordance with the present disclosure.

[0017] FIG. 10 is a cross-sectional view through the section 10-10 of FIG. 9, constructed in accordance with the present disclosure.

[0018] FIG. 11 is a cross-sectional view through the section 11-11 of FIG. 10, illustrating a dosing aperture at a trailing edge of the dosing strut, constructed in accordance with the
10 present disclosure.

[0019] FIG. 12 is a cross-sectional view similar to FIG. 11, but with the dosing aperture being located on a suction side of the dosing strut, constructed in accordance with the present disclosure.

[0020] FIG. 13 is a cross-sectional view through the turbine section of the turbocharger
15 similar to FIG. 3, but with the DEF dosing structure having a different configuration and lacking the dosing cup, constructed in accordance with the present disclosure.

[0021] FIG. 14 is a cross-sectional view through the section 14-14 of FIG. 13, illustrating an airfoil shape of the dosing strut of FIG. 13, constructed in accordance with the present disclosure.

[0022] FIG. 15 is a cross-sectional view of the turbine section having an alternative DEF dosing structure in the turbine diffuser, constructed in accordance with the present disclosure.

[0023] FIG. 16 is a perspective view of the turbine section of FIG. 15, constructed in accordance with the present disclosure.

[0024] FIG. 17 is a cross-sectional view similar to FIG. 15 but with struts of the DEF dosing structure at an angle, constructed in accordance with the present disclosure.
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[0025] FIG. 18 is a cross-sectional view through the DEF dosing structure similar to the DEF dosing structure of FIG. 15 but with the DEF dosing structure having a venturi, constructed in accordance with the present disclosure.

[0026] FIG. 19 is a flowchart illustrating a series of steps that may be involved in dosing DEF into the exhaust gas flowing through the diffuser of the turbocharger using the DEF dosing structure, in accordance with a method of the present disclosure.

DETAILED DESCRIPTION

[0027] FIG. 1 is a schematic view of an exemplary engine system 10. The engine system 10 may be installed in a vehicle or may be installed in a stationary application (e.g., a generator set). The engine system 10 includes a diesel engine 12 having an intake manifold 14 to supply intake air 15 to the combustion chambers of the engine 12 for combustion. In many diesel engines 12, diesel fuel is injected directly into the combustion chambers of the engines. The engine system 10 further includes an exhaust manifold 16 that directs exhaust gas generated in the engine 12 to an exemplary turbocharger 18. The turbocharger 18 uses the exhaust flow to increase the boost pressure of the intake air 15 that is supplied to the engine 12 under certain operating conditions, providing an increase in the engine's power density by allowing more fuel to be combusted. Optionally, the engine system 10 may also include an exhaust gas recirculation (EGR) system 20 for recirculating the exhaust gas back to the engine 12 to reduce combustion temperatures and the formation of NO_x in the engine.

[0028] The turbocharger 18 includes a compressor section 22 having a compressor wheel 24 and a turbine section 26 having a turbine wheel 28. A shaft 30 rotatably couples the compressor wheel 24 and the turbine wheel 28. The flow of the exhaust gas through the turbine section 26 causes the turbine wheel 28 to rotate, thereby driving the rotation of the compressor wheel 24 via the shaft 30. The rotating compressor wheel 24 pressurizes the intake air 15 being supplied to the engine 12 through the intake manifold 14. The pressurized

intake air 15 has a higher density for a given volume, and therefore more oxygen, than air at atmospheric pressure. As a result, more fuel can be added to the pressurized intake air 15 at a given air/fuel ratio. Consequently, the engine 12 can generate more power and torque by combusting a greater quantity of fuel using the pressurized intake air 15.

5 **[0029]** After passing through the turbine section 26, exhaust gas 35 flows through an exhaust pipe 32. The exhaust pipe 32 directs the exhaust gas 35 to one or more aftertreatment devices 34 that may remove or chemically convert pollutants in the exhaust gas 35 prior to release of the exhaust gas 35 into the atmosphere. The one or more aftertreatment devices 34 may include a selective catalytic reduction (SCR) aftertreatment system 36 having an SCR
10 catalyst 38 that catalyzes the reduction of NO_x in the exhaust gas stream to nitrogen in the presence of a reducing agent (ammonia) or a reducing agent source, such as diesel exhaust fluid (DEF). As is understood by those with ordinary skill in the art, DEF is a solution of urea in water.

15 **[0030]** The turbocharger 18 may further include a DEF dosing system 40 that supplies the DEF to the turbine section 26 downstream of the turbine wheel 28. The DEF dosing system 40 may include a pump 42 that pumps the DEF from a DEF tank 44 into one more delivery conduits 46. The one or more delivery conduits 46 are operable to deliver the DEF to the exhaust pipe. The high temperature and high velocity of the exhaust gases downstream of the turbine wheel 28 may promote the thermal decomposition and thorough mixing of the DEF
20 with the exhaust gas 35 to enhance the efficiency of the catalytic reaction at the SCR aftertreatment system 36.

25 **[0031]** As illustrated in FIG. 1, the SCR catalyst 38 is positioned in a second aftertreatment device 34. Persons having ordinary skill in the art would understand that in various embodiments described herein, the SCR catalyst 38 may be a first aftertreatment device 34 and that the SCR catalyst 38 may be closely positioned to the one or more DEF delivery

conduits 46. In various embodiments disclosed herein, engine systems include a DEF dosing structure disposed downstream of the turbine wheel 28 to promote rapid thermal decomposition and mixing of the DEF in the exhaust gas 35 (see further details below).

[0032] The structure of the turbine section 26 is shown in more detail in FIG. 2. It is noted that the components of the DEF dosing system 40 have been removed from the turbine section 26 of FIG. 2 for clarity purposes. The turbine section 26 includes a turbine housing 50 surrounding the turbine wheel 28 and defining a turbine inlet 52 (or volute) through which the exhaust gas 35 produced by the engine 12 is directed to the turbine wheel 28. After exiting the turbine wheel 28, the exhaust gas 35 flows as an annular flow field 54 about a centerline 56 of the turbine wheel 28 into a turbine diffuser 58. The annular flow field 54 flows downstream of a plurality of blades 60 of the turbine wheel 28 and may circumscribe a nose 62 of the turbine wheel 28. The turbine diffuser 58 may be defined by a diverging diffuser wall 64. As explained in more detail below, a DEF dosing structure 48 may be placed in the turbine diffuser 58 to promote thermal decomposition of the DEF and rapid mixing of the DEF with the exhaust gas 35 as the exhaust gas 35 and DEF flow downstream of the turbine wheel 28.

[0033] Turning now to FIG. 3, an exemplary DEF dosing structure 48a according to one embodiment is shown positioned in the turbine diffuser 58 of the turbine section 26. Only the portion of the turbine section 26 above the centerline 56 is shown in FIG. 3. The DEF dosing structure 48a includes a center body 66 and a plurality of struts 68 integrally formed with or affixed to the center body 66 and extending radially from the center body 66 to the diffuser wall 64. FIG. 5 is a perspective view of the DEF dosing structure 48a disposed in the diffuser 58. The struts 68 may be affixed to the diffuser wall 64, such as by welding, or may be integrally formed with the diffuser wall 64, such as by casting. At least one of the struts 68 is a dosing strut 70 through which DEF 72 (or other reducing agent or reducing agent precursor)

is introduced to the center body 66. Specifically, the diffuser wall 64 includes an aperture 75 aligned with or otherwise in fluid communication with a dosing channel 74 through which the DEF 72 is fed from the delivery conduit 46 into the dosing channel 74, such as through a pipe or pressure fitting. As shown in FIG. 3, the dosing channel 74 extends radially through the dosing strut 70 and is in fluid communication with one or more apertures 76 in the center body 66. The one or more apertures 76 in the center body 66 are in fluid communication with the exhaust gas on an upstream end of the center body 66. The DEF 72 flows through the dosing channel 74 and the one or more apertures 76 to be released in an upstream direction toward the nose 62 of the turbine wheel 28.

[0034] Referring to FIGS. 3 and 4, in at least one embodiment, the nose 62 of the turbine wheel 28 includes a dosing cup 78 affixed thereto (e.g., by welding, milling, or mechanical fastening) or integrally formed therewith that receives the DEF 72 being expelled from the dosing aperture 76. The dosing cup 78 rotates with the turbine wheel 28. As a result, the DEF 72 received into the dosing cup 78 is then dispersed from the dosing cup 78 into the exhaust gas stream. Stated differently, the rotating dosing cup 78 may fling the DEF 72 radially outward into the exhaust gas 35 stream. Moreover, the turbine wheel 28 and the dosing cup 78 may be at a high temperature during operation. The high temperature of the dosing cup 78 may facilitate thermal decomposition of the DEF 72 received therein. As shown in FIG. 3, the dosing cup 78 may have a diverging wall to assist in the dispersion of the DEF into the exhaust gas 35. Specifically, the diverging wall urges the DEF 72 toward the opening of the dosing cup 78 as the DEF is flung radially outward by the rotating dosing cup 78.

[0035] Referring to FIG. 5, the DEF dosing structure 48a may also include one or more structural struts 80 that improve the strength of the DEF dosing structure 48a. As used herein, a “structural strut” is a strut of the DEF dosing structure that is used for structural

support only and does not participate in the dosing of the DEF 72, and a “dosing strut” is involved in dosing the DEF 72 into the exhaust gas stream. The structural struts 80 may have a solid construction without a dosing channel for delivering the DEF 72. For example, one of the struts 68 of the dosing structure 48a may be a dosing strut 70, and a remainder of the struts 68 may be structural struts 80. In the embodiment of FIG. 5, the dosing structure 48a includes three struts 68, wherein one of the struts 68 is a dosing strut 70 and the remaining two struts 68 are structural struts 80. In other embodiments, the dosing structure 48a may have more or fewer than three struts 68, and any non-zero number of the struts 68 may be dosing struts 70.

[0036] Turning to FIG. 6, the DEF 72 is directed into the dosing channel 74 through the aperture 75 along the diffuser wall 64 and flows radially inward toward the center body 66. At the center body 66, the dosing channel 74 turns in an upstream direction (such as by about 90°) toward the nose 62 of the turbine wheel 28 and the dosing cup 78 to allow the DEF 72 to be expelled toward the dosing cup 78 via the dosing aperture 76 on the center body 66 (also see FIG. 5).

[0037] In the configuration of FIG. 6, the DEF 72 flows within the walls that define the dosing channel 74. FIG. 7 illustrates an alternative embodiment for a dosing structure 48b in which a delivery pipe 82 extends through the dosing channel 74, and the DEF 72 flows through the delivery pipe 82 to the dosing cup 78. The struts 68 and the center body 66 of the dosing structure 48b shown in FIG. 7 shield the delivery pipe 82 from pressure wave-induced vibrations in the turbine diffuser 58. Such shielding may prevent breakage of the delivery pipe 82. In either the dosing structure 48a (without the delivery pipe 82) or the dosing structure 48b (with the delivery pipe 82), the DEF 72 may follow an “L” shaped path that begins in a radially inward direction and turns upstream (by about 90°) at the center body 66 toward the turbine nose 62.

[0038] FIG. 8 is a cross-sectional view of an optional, exemplary strut 68a (any of the dosing struts 70 and/or the structural struts 80) according to at least one embodiment. As illustrated, the strut includes an airfoil shape with a leading edge 84, a trailing edge 86, a suction side 88, and a pressure side 90. The leading edge 84 of each of the struts 68a may be oriented upstream (toward the turbine wheel 28) and the trailing edge 86 may be oriented downstream (toward the exhaust pipe 32). The airfoil shape of the struts 68a with the trailing edge 86 oriented downstream may reduce drag effects on the exhaust gas. The airfoil shape may also support the structural robustness of the struts 68a positioned in the annular flow field 54 of the exhaust gas, while also reducing vibrations at the turbine wheel 28 caused by reflected pressure waves from the struts 68a. In other embodiments, the struts 68 may have another type of aerodynamic shape (e.g., a symmetrical shape wherein the suction side 88 and the pressure side 90 are mirror images). In at least one embodiment, the airfoil-shaped struts 68a are oriented in the diffuser 58 at an angle of attack relative to the flow direction of the exhaust gas 35. Arranging the airfoil-shaped struts 68a at an angle of attack may change the flow directions of the exhaust gas 35 passing between the struts 68a and such changing flow directions of the exhaust gas 35 may promote mixing of the DEF 72 into the exhaust gas 35. In at least one embodiment, the airfoil shapes of the struts 68a may include camber such that the flow direction of the exhaust gas 35 approaching the leading edges 84 of the struts 68a is different from the flow direction of the exhaust gas 35 departing the trailing edges 86 of the struts 68a. Stated differently, the camber of the airfoil may change the flow direction of the exhaust gas 35 to promote mixing.

[0039] Referring back to FIGS. 6-7, the center body 66 may have a trailing edge 92 oriented in the downstream direction to promote the flow of the DEF into the “wake” of the turbine wheel nose 62. The trailing edge 92 of the center body 66 may promote flow of the exhaust gas 35 into a region downstream of the center body 66.

[0040] An alternative configuration of the DEF dosing structure 48c is shown in FIGS. 9-10. The DEF dosing structure 48c may have many of the features described above, including the center body 66, and the airfoil-shaped struts 68 affixed to the diffuser wall 64 and extending radially between the center body 66 and the diffuser wall 64. However, in the configuration of FIGS. 9-10, the DEF 72 may be delivered into the exhaust gas through one or more dosing apertures 76 along the dosing strut 70. The alternative configuration of FIGS. 9-10 may lack the dosing cup 78 at the turbine wheel nose 62. The dosing strut 70 and the center body 66 may together define a hollow interior 94 through which the DEF 72 flows into the DEF dosing structure 48c from the aperture 75 on the diffuser wall 64. The DEF 72 may collect at the bottom of the hollow interior 94 at the center body 66 and may escape through the dosing apertures 76 by evaporation due to the local high temperatures in the turbine diffuser 58. The interior walls of the dosing strut 70 may define the dosing channel 74 through which the DEF 72 flows to the bottom of the center body 66. Alternatively, a delivery pipe may extend through the hollow interior 94 to release the DEF 72 at the bottom of the center body 66.

[0041] Optionally, the dosing strut 70 may have a plurality of the dosing apertures 76 extending along a length of the dosing strut 70, and the dosing apertures 76 may become progressively larger in a radially-outward direction from the center body 66 to the diffuser wall 64, with the smallest dosing aperture 76 being near the center body 66 and the largest dosing aperture 76 being near the diffuser wall 64 (see FIG. 10). The increasing size of the dosing apertures 76 toward the diffuser wall 64 may promote a more uniform flow of the DEF into the exhaust gas by promoting equal mass flow through each of the dosing apertures 76. In other configurations, the dosing apertures 76 may have the same size or variable/random sizes. In the configuration for the DEF dosing structure 48c illustrated in FIGS. 9 and 10, any number of the struts could be dosing struts 70. Specifically, one or both

of the illustrated struts 68 could also be dosing struts 70, meaning that the struts would be hollow and would include apertures 76 for dispersal of the DEF.

[0042] The dosing apertures 76 may be along the trailing edge 86 (see FIG. 11) or along the suction side 88 (see FIG. 12) of the airfoil-shaped dosing strut 70 so that the exhaust gas flow may assist the outward flow of the DEF 72 into the exhaust gas stream. However, in alternative arrangements, the dosing apertures 76 may be along the leading edge 84, the pressure side 90, or a combination of the trailing edge 86, the suction side 88, the leading edge 84, and/or the pressure side 90.

[0043] Yet another alternative configuration of the DEF dosing structure 48d in the turbine diffuser 58 is shown in FIGS. 13 and 14. The DEF dosing structure 48d of FIG. 13 is similar to those described above and may include a plurality of struts 68 (including at least one dosing strut 70 and at least one structural strut 80) extending radially from the center body 66 and affixed to the diffuser wall 64. The alternative configuration shown in FIG. 13 may lack the dosing cup 78 at the turbine wheel nose 62, similar to the arrangement of FIGS. 9-10.

However, the center body 66 of the DEF dosing structure 48d of FIG. 13 may have a solid construction (without a flow path for the DEF 72), and the DEF 72 may flow through the dosing channel 74 of the dosing strut 70 and into the exhaust gas stream through the dosing apertures 76 along the dosing strut 70, without passing through the center body 66. In addition, the struts 68 of the DEF dosing structure 48d of FIG. 13 may be angled with respect to a direction of flow of the exhaust gas 35. As shown in FIG. 13, the struts are arranged at angles such that the leading edges 84 of the struts 68, 70, and/or 80 are closer to the turbine wheel 28 where the struts 68, 70, and/or 80 join the center body 66 than where the struts 68, 70, and/or 80 join the diffuser 58. In other embodiments, the struts may be arranged at angles such that the leading edges 84 of the struts 68, 70, and/or 80 are closer to the turbine wheel 28 where the struts 68, 70, and/or 80 join the diffuser 58 than where the struts 68, 70, and/or

80 join the center body 66. The angled struts 68 may reduce the impact of reflected pressure waves from the struts 68 onto the turbine wheel 28, as well as the impact of exhaust gas pressure waves flowing from the turbine wheel 28 onto the struts 68. Accordingly, vibrations at the turbine wheel 28 and at the struts 68 may be reduced, supporting the structural robustness of the DEF dosing structure 48d.

[0044] Furthermore, as above, the struts 68 may have an airfoil shape (with the leading edge 84 oriented upstream toward the turbine wheel 28 and the trailing edge 86 oriented downstream) to reduce drag effects on the exhaust gas and prevent vibrations at the struts 68 and the turbine wheel 28 (see FIG. 14). As shown in FIG. 14, the dosing apertures 76 may be along the suction side 88 of the dosing strut 70. Alternatively, however, the dosing apertures 76 may be along the trailing edge 86, the leading edge 84, the pressure side 90, or along a combination of the trailing edge 86, the leading edge 84, the suction side 88, and/or the pressure side 90. As discussed above, the struts 68 may include an angle of attack and/or camber.

[0045] Another arrangement of the DEF dosing structure 48e is shown in FIGs. 15-16. In this arrangement, the DEF dosing structure 48e may include an annular ring 96 that circumscribes the turbine nose 62 and includes one or more of the dosing apertures 76 through which the DEF 72 is dosed into the exhaust gas. The annular ring 96 may have an elliptical shape in cross-section (as shown in FIG. 15), and may be positioned symmetrically about the centerline 56 downstream of the blades 60 such that the body of the ring 96 lies approximately in the middle of the annular flow field 54 (see FIG. 15). The annular ring 96 may be supported in this position by a plurality of short struts 98 that are affixed to and extend radially between the annular ring 96 and the diffuser wall 64 (see FIGs. 15-16). In some arrangements, the struts 98 may be swept at an angle relative to the axis of rotation of the turbine wheel 28 (see FIG. 17). The annular ring 96 may be less sensitive to vibrations

than the struts 68, discussed above, because it may experience the exhaust flow coming off of the blades 60 as an uninterrupted flow, rather than as pressure pulses. Likewise, vibrations at the turbine wheel 28 may be reduced as reflected pressure waves from the annular ring 96 may be uninterrupted and continuous due to the annular structure of the ring 96.

- 5 Furthermore, the short struts 98 may be stiff and may be structurally robust in the high vibration environment in the turbine diffuser 58.

[0046] The annular ring 96 may have a hollow interior 100 in fluid communication with the dosing apertures 76, and at least one of the struts 98 may have a dosing channel 102 in fluid communication with the hollow interior 100 for delivery of the DEF 72 into the hollow
10 interior 100 (see FIG. 15). The aperture 75 of the diffuser wall 64 may be aligned with or otherwise in fluid communication with the dosing channel 102 so that the DEF 72 may flow into the dosing channel 102 and the hollow interior 100 of the ring 96, and then into the exhaust gas through the dosing apertures 76. The exhaust gas flow from the turbine wheel 28 may split at the annular ring 96 at an upstream side 104 of the ring 96, collect the DEF 72
15 exiting the dosing apertures 76, and recombine at a downstream side 106 of the ring 96 with relatively weak disturbance of the exhaust gas flow due to the elliptical shape of the ring 96.

[0047] The annular ring 96 has a radially outward-facing surface 108 and a radially-inward facing surface 110. The dosing apertures 76 may be arranged along the radially-inward facing surface 110, as shown in FIGs. 15-16. In other arrangements, however, the dosing
20 apertures 76 may be along the radially-outward facing surface 108, the upstream side 104, the downstream side 106, or a combination of the radially inward-facing surface 110, the radially-outward facing surface 108, the upstream side 104, and/or the downstream side 106.

[0048] An alternative configuration of the annular ring 96a for use with a DEF dosing structure 48f is shown in FIG. 18. In this configuration, the ring 96a may include an outer
25 ring 112 having the hollow interior 100 in fluid communication with the dosing channel 102

and the dosing aperture(s) 76, and an inner ring 114 radially inward of and inserted within the outer ring 112. The outer ring 112 and the inner ring 114 may have mirroring converging/diverging surfaces that face one another to define a venturi 116 in an annular space 118 between the outer ring 112 and the inner ring 114. The venturi 116 may create a constricted region 120 in the annular space 118 that assists in the atomization of the DEF 72 that exits the annular ring 96a. To promote atomization, the dosing apertures 76 of the outer ring 112 may be located at the constricted region 120 of the venturi 116. In alternative arrangements, the annular ring 96a may have a plurality of venturis in the annular space 118 between the inner ring 114 and the outer ring 112. The inner ring 114 may be connected the outer ring 112 by various mechanisms, such as by struts between the outer ring 112 and the inner ring 114.

Industrial Applicability

[0049] In general, the teachings of the present disclosure may find applicability in many industries including, but not limited to, automotive industries. More specifically, the teachings of the present disclosure may be applicable to any industry relying on engine systems having a turbocharger and an SCR aftertreatment system.

[0050] FIG. 19 is a flowchart showing a series of steps that may be involved in dosing DEF into the exhaust gas flowing through the turbine diffuser 58 of the turbocharger 18 using any one of the DEF dosing structures 48a-f discussed in the present disclosure (referred to collectively using reference numeral 48) or any other DEF dosing structures. At a first block 130, the DEF may be delivered through a strut (the dosing strut 70 or one of the struts 98) of the DEF dosing structure 48. The block 130 may involve delivering DEF from the DEF tank 44 through the delivery conduit 46 and the diffuser aperture 75 into the dosing channel 74 or 102 (or the delivery pipe 82) of the strut. At a next block 132, the DEF may be dosed into the exhaust gas flowing through the turbine diffuser 58 through one or more dosing apertures 76

of the DEF dosing structure 48. For instance, the dosing aperture 76 may be at an upstream side of the center body 66 to direct the DEF upstream into the dosing cup 78 (see FIGs. 3-7), the dosing apertures 76 may be along the dosing strut 70 (see FIGs. 9-10 and 13), or the dosing apertures 76 may be along the annular ring 96 (see FIGs. 15-18). At a next block 134, the DEF may be permitted to mix with and uniformly disperse into the exhaust gas due to the design of the dosing structure 48 and the high temperature and high velocity environment of the turbine diffuser 58. The mixed DEF and exhaust gas may be supplied to the catalyst 38 of the SCR aftertreatment system 36 at a next block 136.

[0051] The present disclosure provides a DEF dosing structure that is affixed to a turbine diffuser of a turbocharger downstream of the turbine wheel. Placement of the DEF dosing structure in the turbine diffuser takes advantage of the high temperature and high velocity environment of the turbine diffuser to promote uniform dispersion of the DEF into the exhaust gas. Furthermore, the DEF dosing structure includes features that promote the ability of the DEF dosing structure structurally withstand the high vibration environment of the turbine diffuser, while also limiting the magnitude of reflected pressure waves onto the turbine wheel. For instance, the DEF dosing structure may have airfoil shaped struts through which the DEF is dosed into the exhaust gas stream, or it may have an annular ring through which the DEF is dosed into the exhaust gas stream. The annular ring configuration may experience the exhaust gas flow as a continuous pressure wave and may reflect pressure back onto the turbine wheel as a continuous wave, thereby reducing vibrations experienced at the annular ring and at the turbine wheel. In addition, the DEF dosing structure may dose the DEF into the exhaust gas stream through multiple dosing apertures to promote thorough mixing and uniform dispersion in the exhaust gas compared to single point urea injectors of the prior art.

[0052] In existing designs, there are tradeoffs between locating the SCR catalyst closer to or further away from the DEF injection site. Positioning the SCR catalyst closer to the DEF injection site also positions the SCR catalyst closer to the exhaust manifold. As a result, the SCR catalyst is exposed to hotter exhaust gas temperatures, which can increase the effectiveness of the SCR catalyst. Additionally, positioning the SCR catalyst closer to the DEF injection site may result in smaller packaging for the exhaust system. However, positioning the SCR catalyst closer to the DEF injection site can also result in incomplete thermal decomposition and mixing of the DEF with the exhaust gases before the injected DEF arrives at the SCR catalyst. As a result, the catalytic reaction may be less effective. If the SCR catalyst is positioned further from the DEF injection site, the DEF fluid may complete the thermal decomposition process and be better mixed with the exhaust gas. However, the SCR catalyst would be exposed to cooler exhaust gases (due to the increased distance from the exhaust manifold) and the packaging for the exhaust system would be larger.

[0053] Due to the improved mixing of the DEF with the exhaust gas provided by the DEF dosing structures disclosed herein, the SCR catalyst may be placed closer to the exhaust manifold (as is increasingly desired by engine manufacturers), thereby exposing the catalyst to higher exhaust temperatures and providing smaller packaging without compromising the thermal decomposition and mixing of the DEF with the exhaust gas. As such, the overall efficiency of the catalytic conversion at the SCR catalyst may be substantially improved over existing designs. It is expected that the technology disclosed herein may find wide industrial applicability in a wide range of areas such as, but not limited to, automotive applications.

WHAT IS CLAIMED IS:

1. A turbine diffuser configured for use in a turbocharger, comprising:
a diffuser wall defining the diffuser; and
a diesel exhaust fluid (DEF) dosing structure disposed in the diffuser and
5 configured to dose DEF into exhaust gas flowing through the diffuser, the DEF dosing structure being supported in the diffuser by at least two structures affixed to the diffuser wall.
2. The turbine diffuser of claim 1, wherein the DEF dosing structure includes a center body, and wherein the at least two structures are a plurality of struts extending radially from
10 the center body to the diffuser wall.
3. The turbine diffuser of claim 2, wherein at least one of the plurality of struts is a dosing strut having one or more dosing apertures through which the DEF is dosed into the exhaust gas.
4. The turbine diffuser of claim 3, wherein one of the plurality of struts is the dosing
15 strut and a remainder of the plurality of struts are structural struts.
5. The turbine diffuser of claim 3, wherein the dosing strut and the center body define a hollow interior, and wherein the one or more dosing apertures are configured to permit the DEF to escape from the hollow interior into the exhaust gas.
6. The turbine diffuser of claim 5, wherein the dosing strut includes a plurality of the
20 dosing apertures extending along a length of the dosing strut from the center body to the diffuser wall, and wherein the plurality of the dosing apertures become progressively larger from the center body to the diffuser wall.
7. The turbine diffuser of claim 3, wherein the plurality of struts are angled with respect to a direction of flow of the exhaust gas, wherein the dosing strut includes a hollow interior,

and wherein the one or more dosing apertures are configured to permit the DEF to escape from the hollow interior into the exhaust gas.

8. The turbine diffuser of claim 3, wherein the plurality of struts have an airfoil cross-sectional shape with a leading edge oriented upstream, a trailing edge oriented downstream, a suction side, and a pressure side.

9. The turbine diffuser of claim 8, wherein the one or more dosing apertures are along the trailing edge of the dosing strut.

10. The turbine diffuser of claim 8, wherein the one or more dosing apertures are along the suction side of the dosing strut.

11. The turbine diffuser of claim 1, wherein the DEF dosing structure includes an annular ring having a plurality of dosing apertures through which the DEF is dosed into the exhaust gas flowing through the diffuser.

12. The turbine diffuser of claim 11, wherein the at least two structures are a plurality of struts extending radially between the annular ring and the diffuser wall, and wherein each of the plurality of struts are affixed to the annular ring.

13. The turbine diffuser of claim 12, wherein:

the annular ring includes a hollow interior in fluid communication with the dosing apertures; and

at least one of the plurality of struts includes a dosing channel in fluid communication with the hollow interior, the DEF being delivered into the hollow interior of the annular ring through the dosing channel, the DEF being dosing from the hollow interior into the exhaust gas through the plurality of dosing apertures of the annular ring.

14. The turbine diffuser of claim 13, wherein the annular ring has an elliptical shape in cross-section.

15. A turbocharger for an engine system having an exhaust pipe with a selective catalytic reduction (SCR) aftertreatment system for treating an exhaust gas, comprising:

a compressor section;

5 a turbine section rotatably coupled to the compressor section via a shaft, the turbine section including a turbine wheel having a nose and a plurality of blades, and a turbine diffuser downstream of the turbine wheel, the turbine diffuser being defined by a diffuser wall; and

a diesel exhaust fluid (DEF) dosing structure disposed in the turbine diffuser downstream of the turbine wheel and configured to dose DEF into the exhaust gas
10 flowing through the diffuser, the DEF dosing structure being supporting in the diffuser by at least two structures affixed to the diffuser wall.

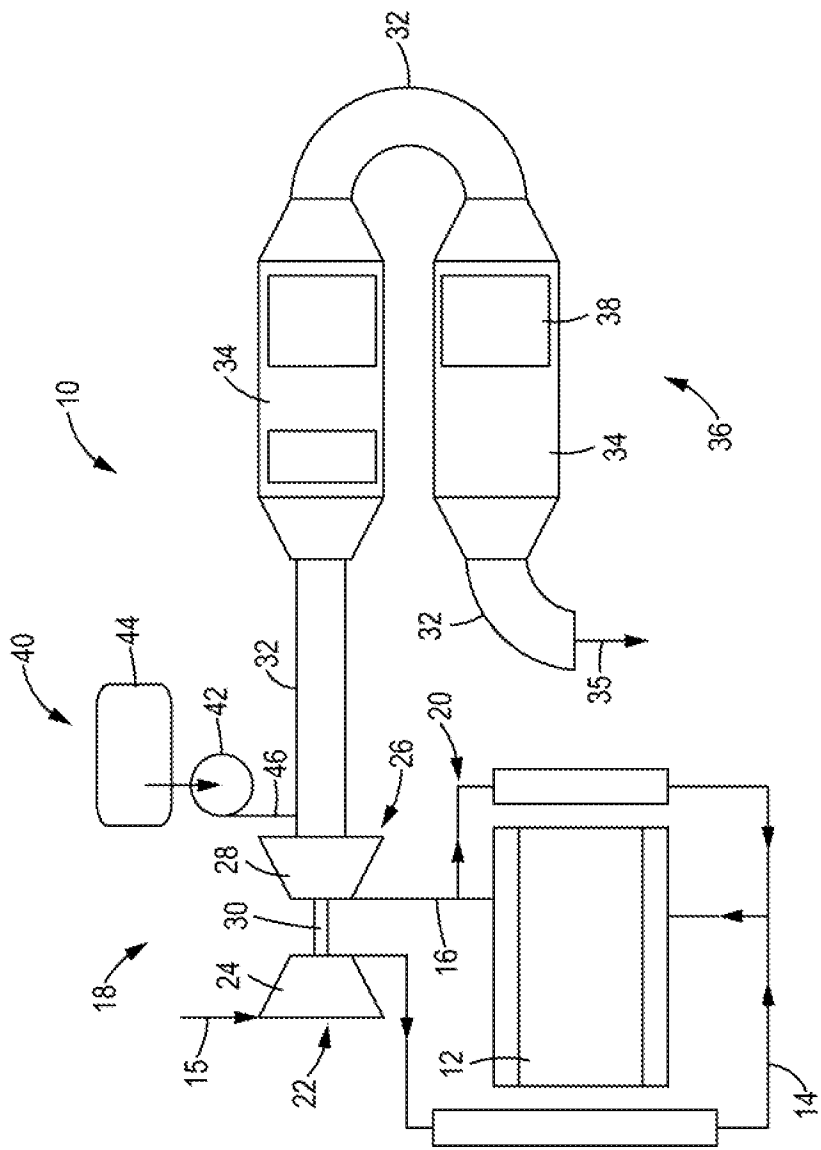


FIG. 1

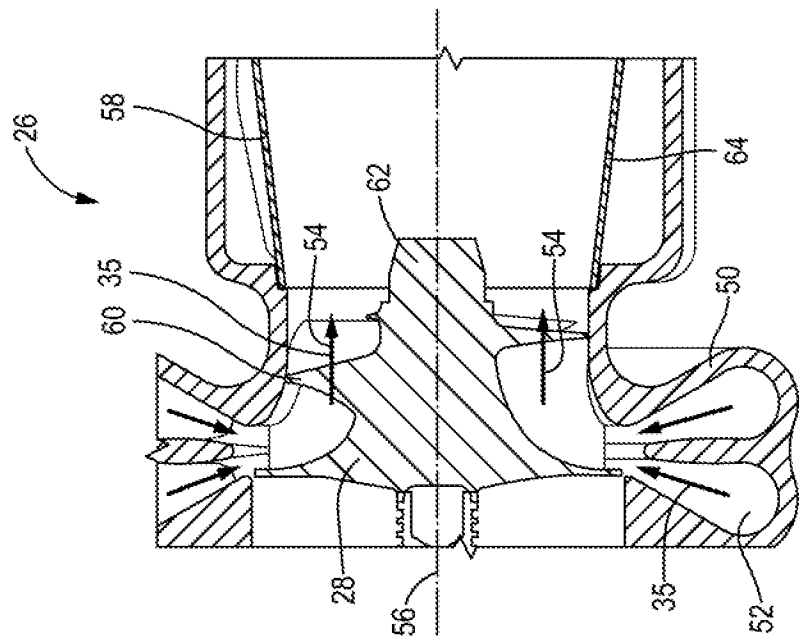


FIG. 2

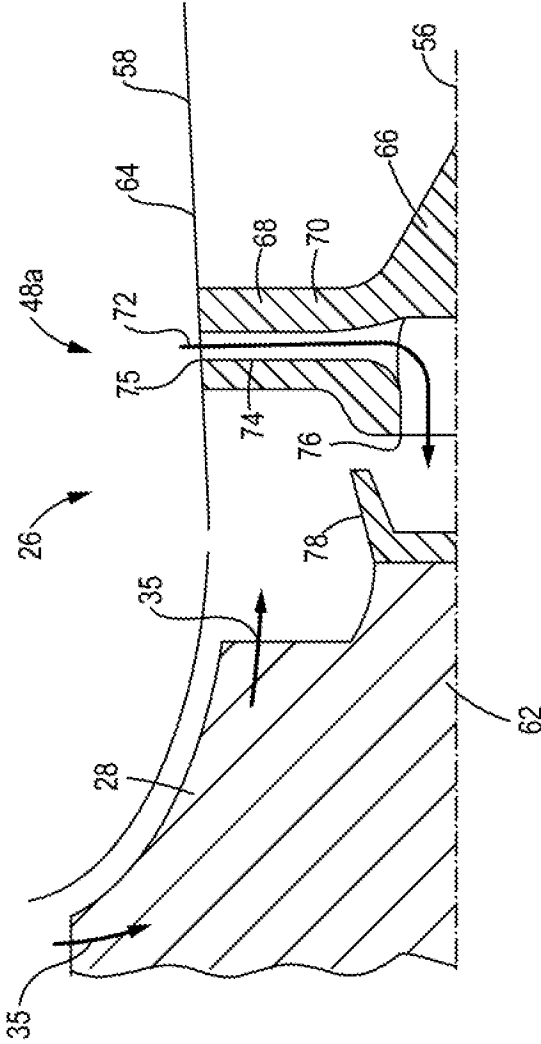


FIG. 3

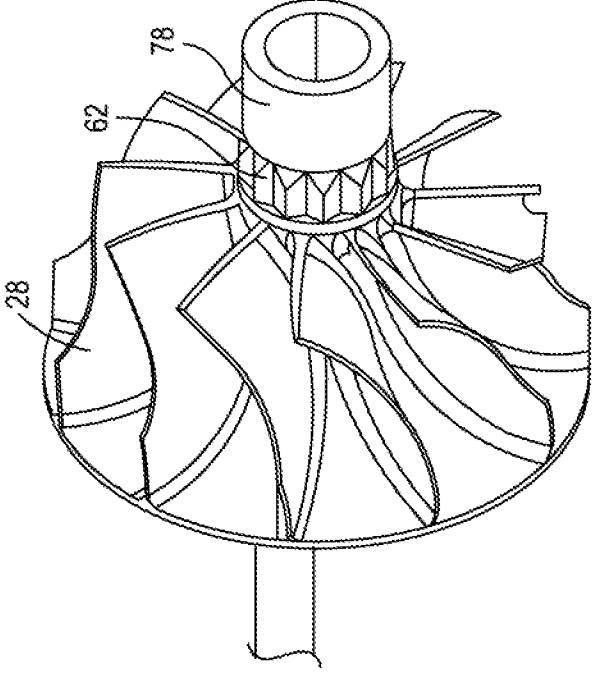


FIG. 4

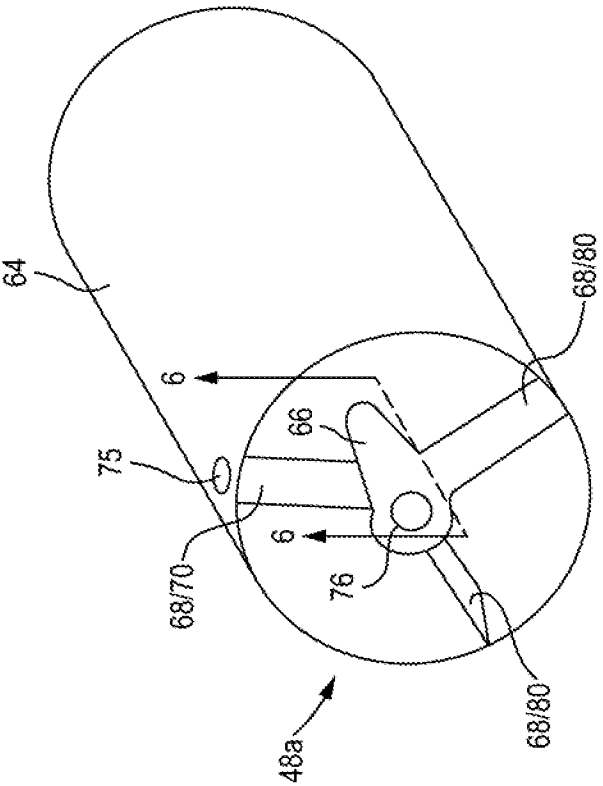


FIG. 5

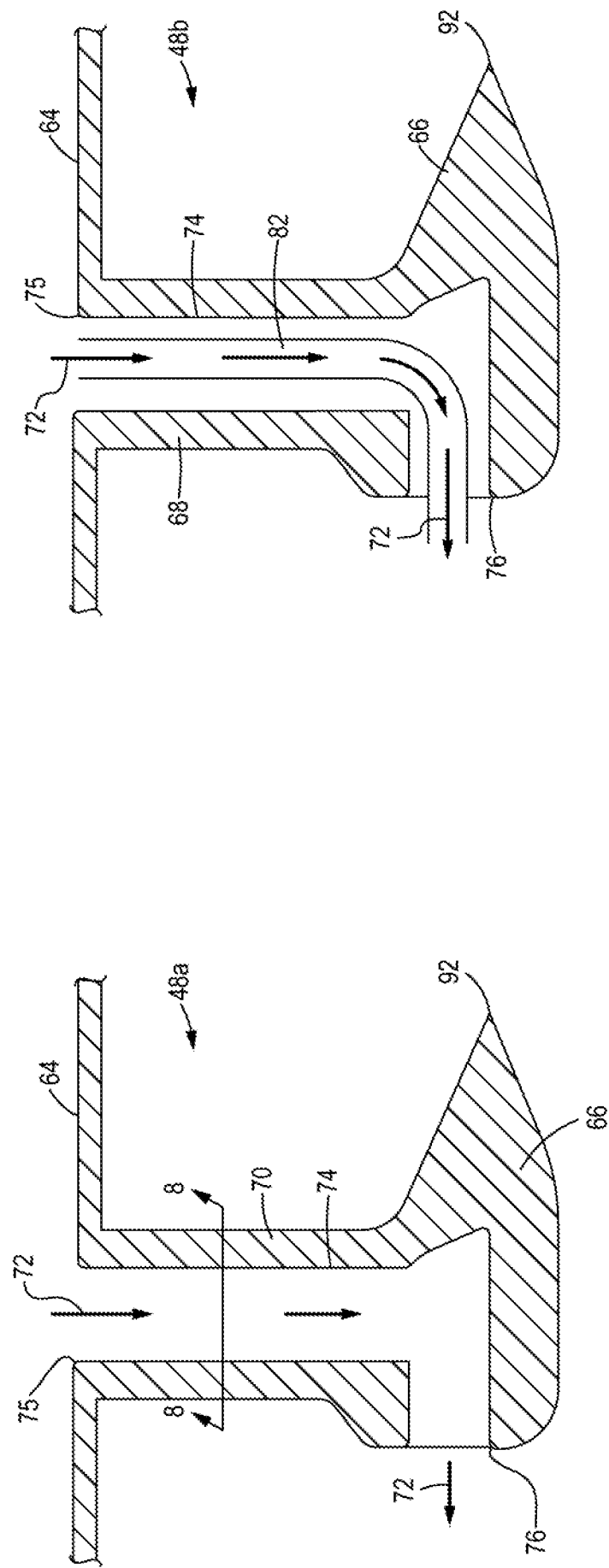


FIG. 7

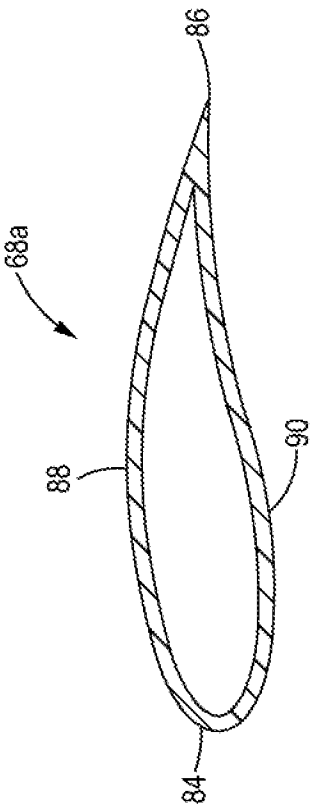


FIG. 8

FIG. 6

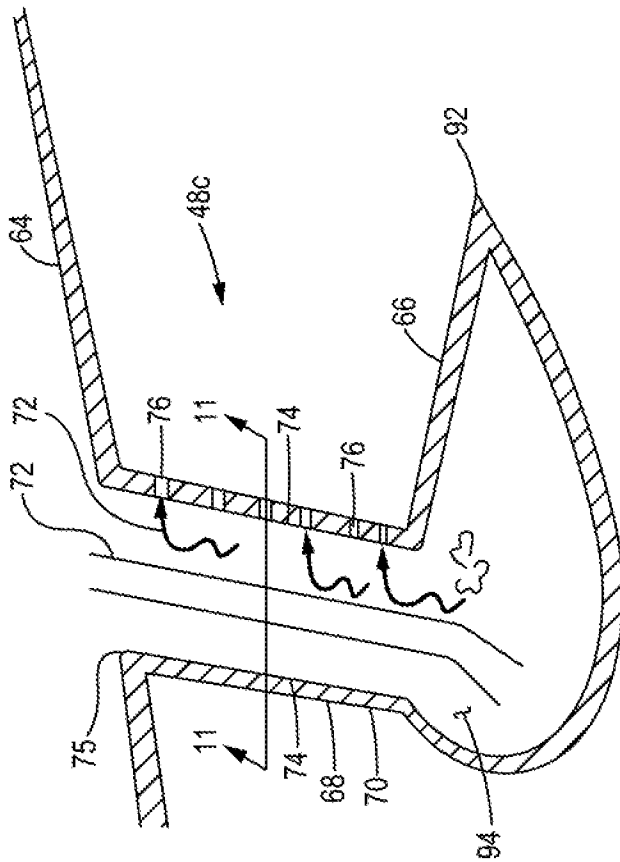


FIG. 10

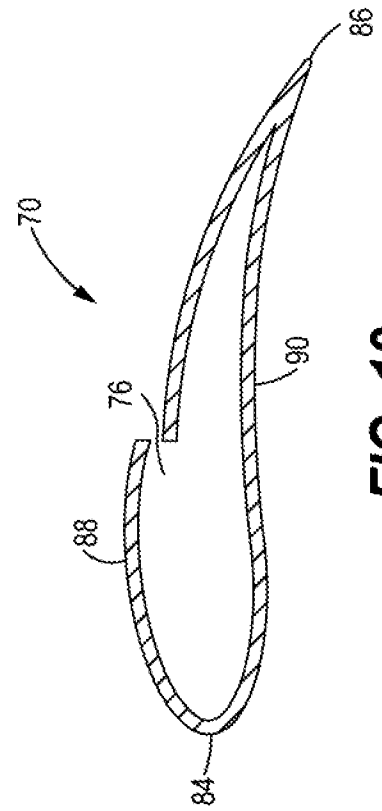


FIG. 12

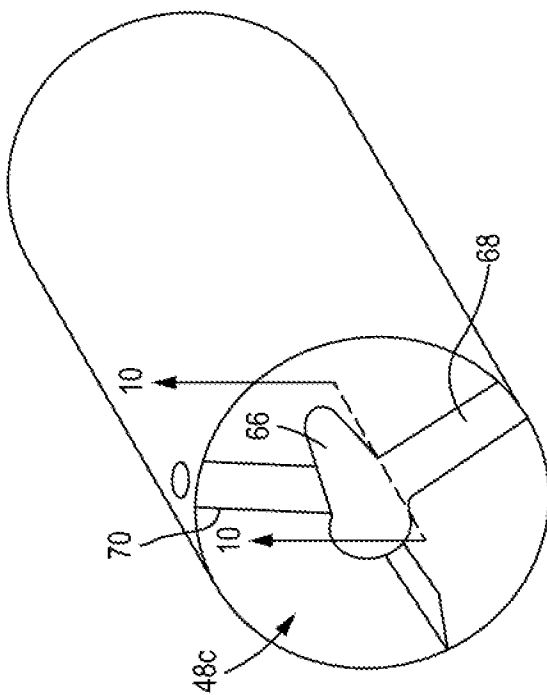


FIG. 9

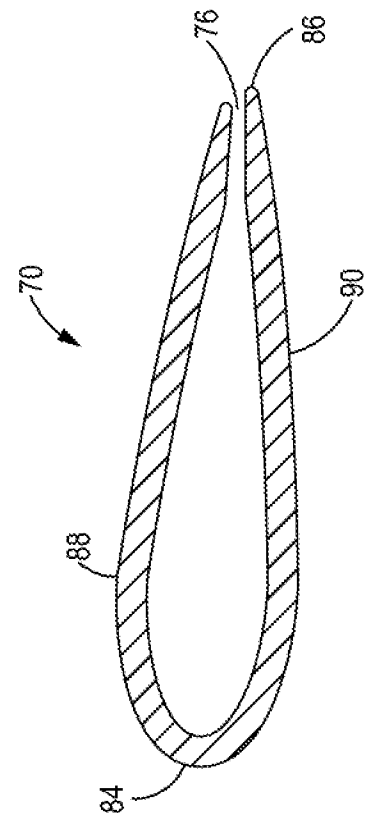


FIG. 11

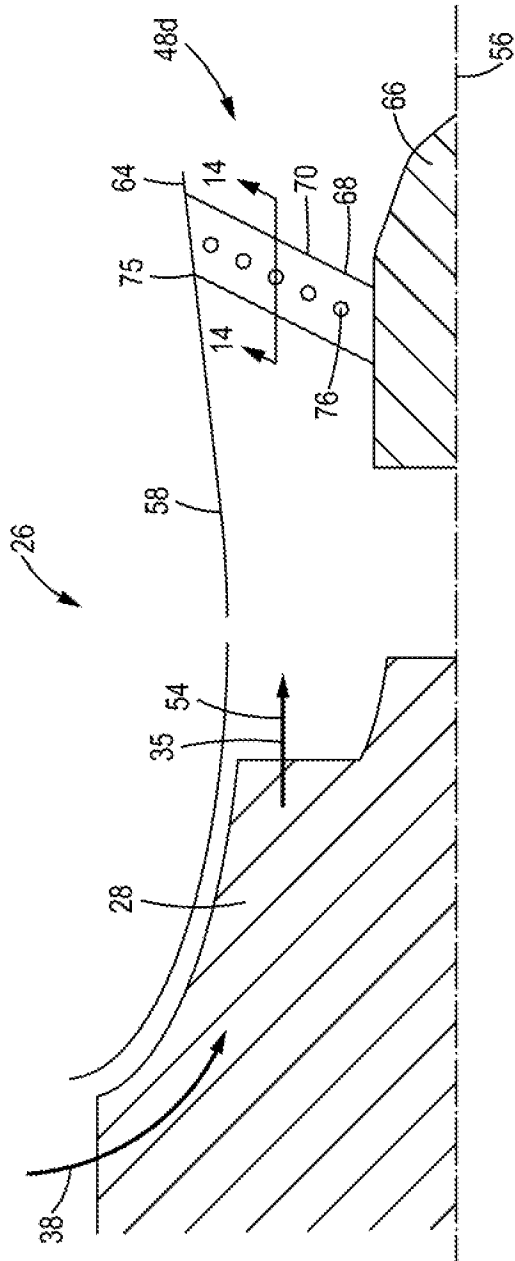


FIG. 13

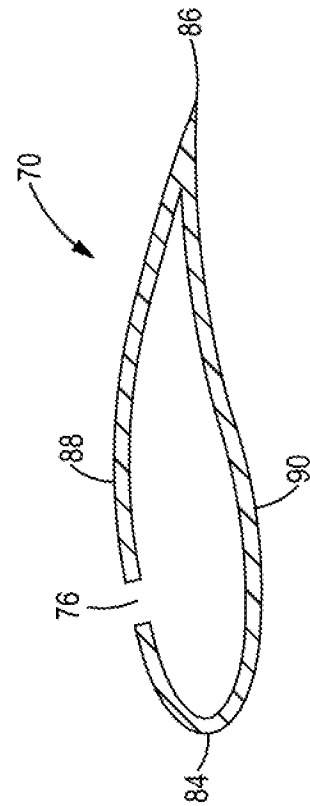


FIG. 14

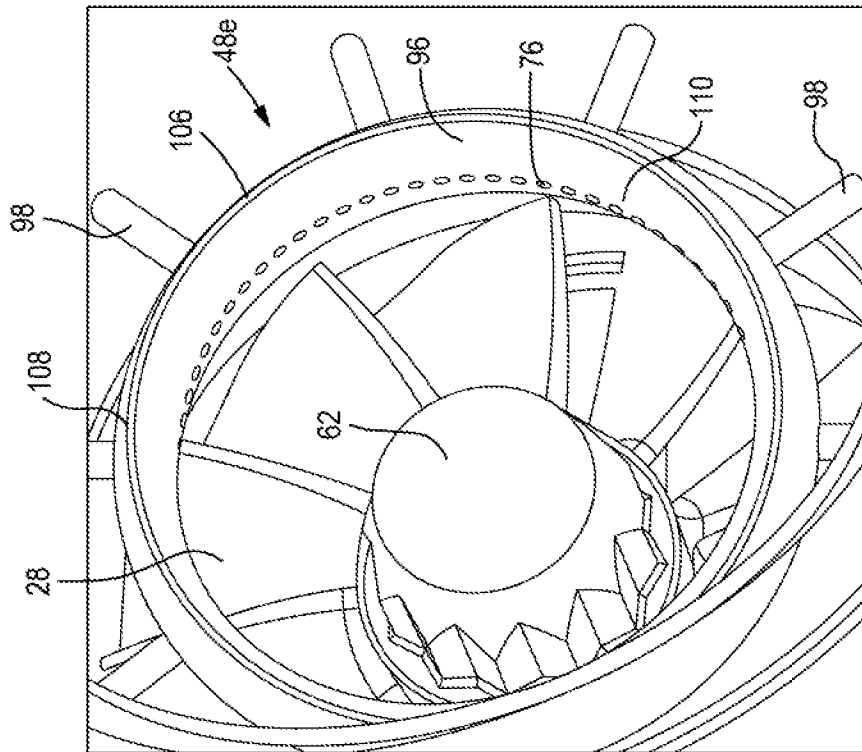


FIG. 16

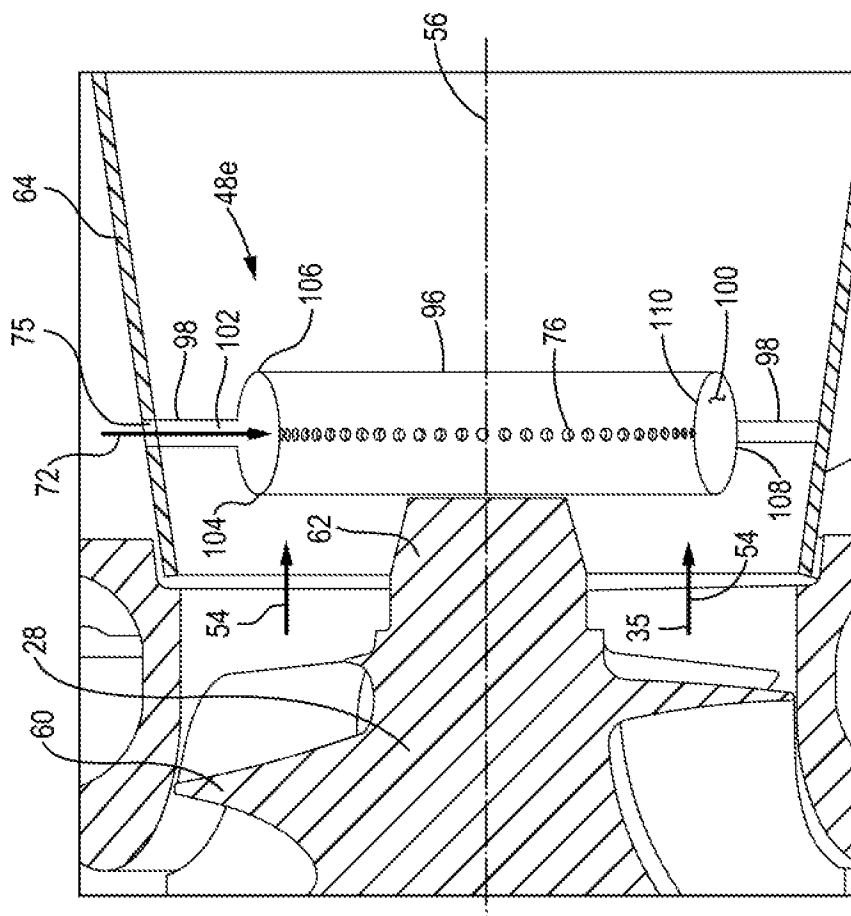


FIG. 15

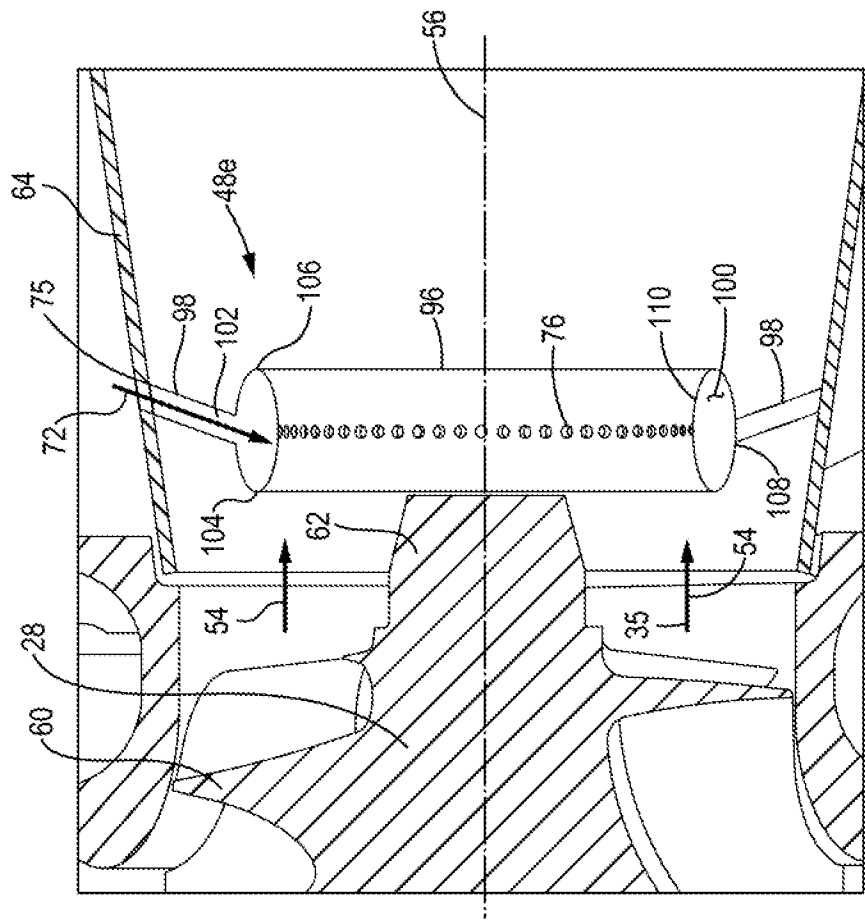


FIG. 17

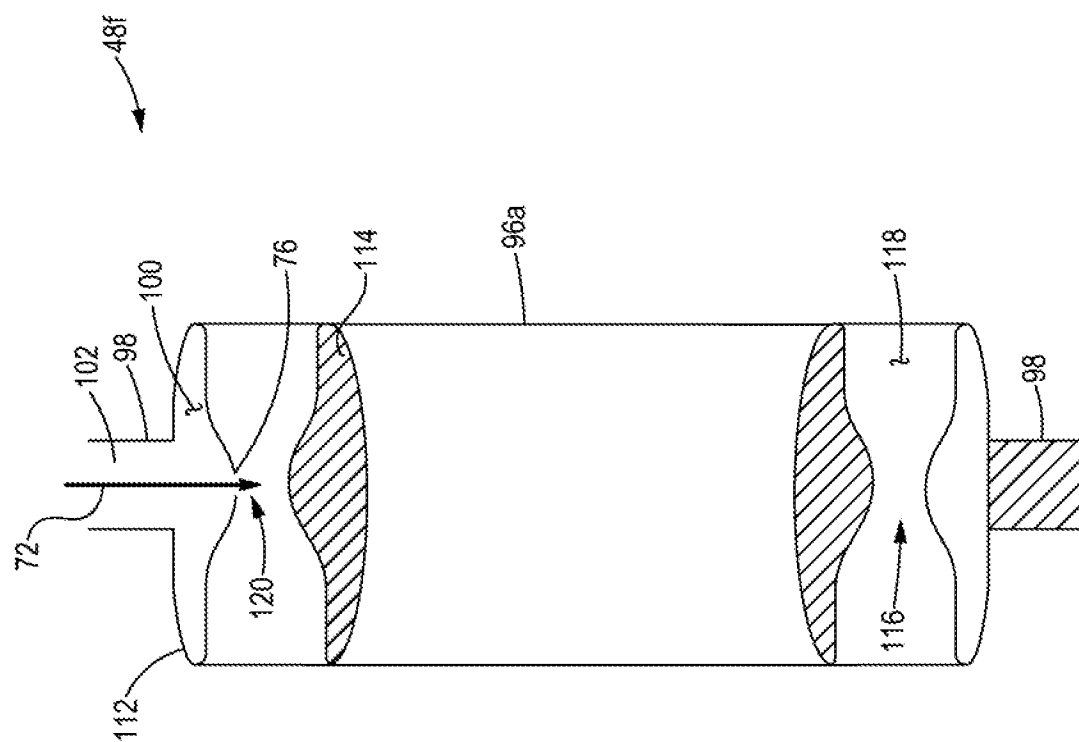
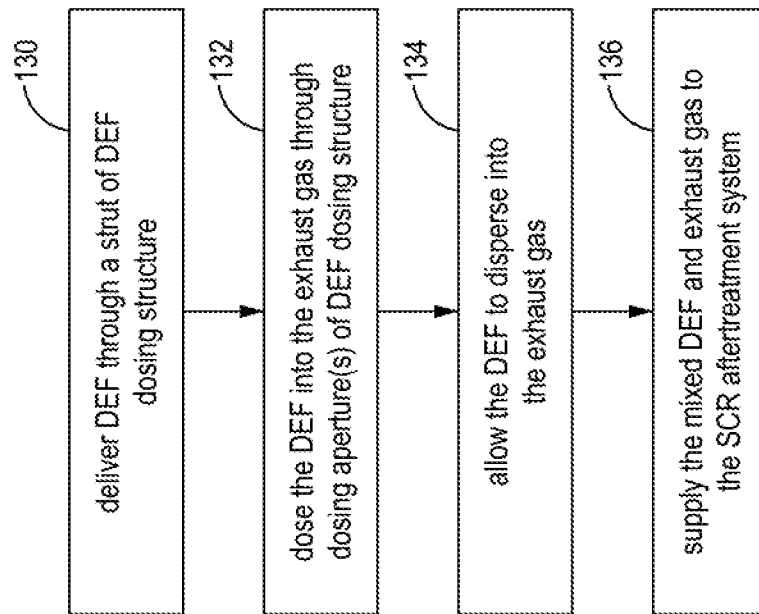


FIG. 18

**FIG. 19**

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2019/041527

A. CLASSIFICATION OF SUBJECT MATTER
INV. F01D25/30 F01N3/20 F02B37/00 F02B39/00
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
F01D F01N F02B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2016/173700 A1 (MTU FRIEDRICHSHAFEN GMBH [DE]) 3 November 2016 (2016-11-03) page 14, line 30 - page 15, line 24; figures 1,2	1-15
A	WO 2018/080371 A1 (SCANIA CV AB [SE]) 3 May 2018 (2018-05-03) page 14, line 24 - page 15, line 7; figure 2	1-15
A	WO 01/96718 A1 (VOLVO LASTVAGNAR AB [SE]; MEGAS LUCAS [SE] ET AL.) 20 December 2001 (2001-12-20) page 4, line 29 - page 5, line 12; figures	1-15
A	EP 1 767 755 A2 (MAN NUTZFAHRZEUGE AG [DE]) 28 March 2007 (2007-03-28) paragraphs [0021] - [0023]; figure 1	1-15



Further documents are listed in the continuation of Box C.



See patent family annex.

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

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"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

6 September 2019

Date of mailing of the international search report

27/09/2019

Name and mailing address of the ISA/

European Patent Office, P.B. 5818 Patentlaan 2
NL - 2280 HV Rijswijk
Tel. (+31-70) 340-2040,
Fax: (+31-70) 340-3016

Authorized officer

Blanc, Sébastien

INTERNATIONAL SEARCH REPORT

Information on patent family members

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