(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 4 560 122 A1

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
28.05.2025 Bulletin 2025/22

(21) Application number: **23212333.1**

(22) Date of filing: **27.11.2023**

(51) International Patent Classification (IPC):
F01N 1/24 *(2006.01)* ***F01N 3/021*** *(2006.01)*
F01N 3/10 *(2006.01)*

(52) Cooperative Patent Classification (CPC):
F01N 1/24; F01N 1/003; F01N 13/0097;
F01N 3/021; F01N 3/10; F01N 2260/20;
F01N 2310/02; F01N 2590/08

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC ME MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA
Designated Validation States:
KH MA MD TN

(71) Applicant: **Scania CV AB**
151 87 Södertälje (SE)

(72) Inventors:
- **VENNBERG ERIKSSON, Mattias**
  12266 Enskede (SE)
- **SVENSSON, Joel**
  89136 Örnsköldsvik (SE)
- **GAGIU, Rainer**
  16855 Bromma (SE)
- **TRIFAUT, Romane**
  15168 Södertälje (SE)
- **ROSSI FERRINI, JACOPO**
  15133 Södertälje (SE)
- **PEERLINGS, Luck**
  12143 Johanneshov (SE)
- **VEJENDLA, Balaji**
  64634 Gnesta (SE)

(74) Representative: **Scania CV AB**
Patents, GP 117kv
151 87 Södertälje (SE)

(54) **EXHAUST ASSEMBLY, INTERNAL COMBUSTION ENGINE, AND VEHICLE**

(57) An exhaust assembly (1) for an internal combustion engine (40) is disclosed. The exhaust assembly (1) comprises a housing (3) comprising an exhaust inlet (11), an exhaust outlet (12), and an inner surface (3') delimiting an inner volume (V) of the housing (3). The exhaust assembly (1) further comprises an exhaust aftertreatment unit (u1) arranged inside the inner volume (V). The exhaust aftertreatment unit (u1) comprises an outlet (u1") fluidly connected to the inner volume (V) of the housing (3). The exhaust assembly (1) further comprises at least one perforated wall (w1, w2) arranged inside the inner volume (V) of the housing (3) and a noise attenuating material (9, 9') placed between the at least one perforated wall (w1, w2) and the inner surface (3') of the housing (3). The present disclosure further relates to an internal combustion engine (40) and a vehicle (2) comprising an internal combustion engine (40).

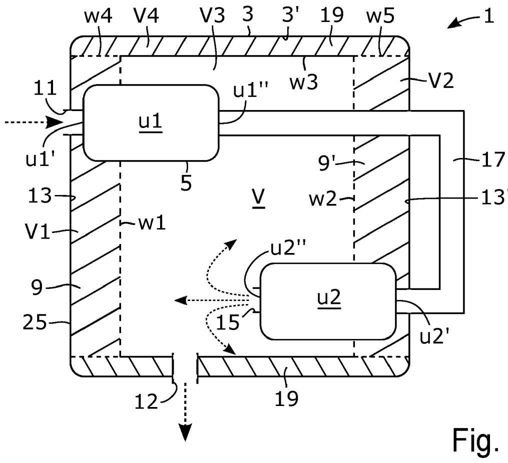

Fig. 3

Processed by Luminess, 75001 PARIS (FR)

Description

TECHNICAL FIELD

[0001] The present disclosure relates to an exhaust assembly for an internal combustion engine. The present disclosure further relates to an internal combustion engine comprising an exhaust assembly, as well as a vehicle comprising an internal combustion engine.

BACKGROUND

[0002] Exhaust systems for combustion engines are used to manage and expel the exhaust gases from the engine, and to reduce environmental impact and noise pollution. An effective exhaust system is important for maintaining the efficiency of the combustion engine and ensuring compliance with regulations. An exhaust system may comprise several components, including but not limited to an exhaust manifold, a number of exhaust ducts, catalytic converters, particulate filters, sensors, mufflers, and the like.

[0003] Mufflers are implemented to suppress the noise generated by the high-velocity and pulsating flow of exhaust gases. The acoustic performance of the exhaust system in vehicles is important as it directly affects the comfort of the passenger or operator by reducing sound pressure and noise levels. The industry currently utilizes dissipative mufflers, which use absorbing materials to diminish noise, and reactive mufflers, which include resonators tuned to specific frequencies and expansion chambers effective in lower frequency ranges to reflect sound waves back towards their source.

[0004] Conventional exhaust systems usually comprise at least two units connected by piping, wherein the units form different volumes used for different purposes, such as for attenuating noise, for performing a catalytic reduction, for trapping particles in the exhaust gas, and the like purposes. In other words, exhaust systems of modern vehicles usually comprise a number of units arranged in series in a piping system of the exhaust system. If additional dampening is required, then an additional box, sometimes referred to as a "stack" or "secondary silencer", is often added to the exhaust system, which adds complexity, weight, and costs to the exhaust system.

[0005] Exhaust systems of combustion engines can cause packing problems in a vehicle. The available space in a vehicle is normally limited by other components and systems of the vehicle. Moreover, an internal combustion engine normally produces hot exhaust gases which also can be further heated by an exothermic reaction in one or more catalysts of the exhaust system.

[0006] High external temperatures of components of an exhaust system poses a problem because heat radiating from the component may damage adjacent components like sensor cables, rubber hoses, mudguards, wooden floors, and the like. Moreover, high external temperatures of components of an exhaust system may cause injury to individuals from accidental contact with the hot component.

[0007] Furthermore, high external temperatures of components of an exhaust system can add to the packing problems caused by an exhaust system because of the need for void spaces around the components, as well as a need for external thermal insulation, heat shields, and the like.

[0008] Many exhaust aftertreatment units, such as catalytic converters, require an internal temperature above an operational temperature threshold to function properly. A problem with these types of units is that it can take considerable time from the startup of an engine until the internal temperature of the exhaust aftertreatment unit reaches above the operational temperature threshold. Moreover, under some operational conditions, such as long lasting idling period, coasting situations with the vehicle, and the like, the temperature of the exhaust aftertreatment unit may decline below the operational temperature threshold which may significantly reduce the operational efficiency of the exhaust aftertreatment unit.

[0009] Moreover, the assembly costs of various vehicle components constitute a significant proportion of the vehicle's final production cost. Therefore, generally, it is an advantage if products, such as exhaust systems and their and their constituent components, have conditions and characteristics suitable for being assembled in a cost-efficient manner.

SUMMARY

[0010] It is an object of the present invention to overcome, or at least alleviate, at least some of the above-mentioned problems and drawbacks. The object is achieved by the subject-matter of the appended independent claim(s).

[0011] According to a first aspect of the present disclosure, the object is achieved by an exhaust assembly for an internal combustion engine, wherein the exhaust assembly comprises a housing comprising an exhaust inlet, an exhaust outlet, and an inner surface delimiting an inner volume of the housing. The exhaust assembly further comprises a first exhaust aftertreatment unit arranged inside the inner volume. The first exhaust aftertreatment unit comprises an inlet fluidly connected to the exhaust inlet of the housing and an outlet fluidly connected to the inner volume of the housing. The exhaust assembly further comprises at least one perforated wall arranged inside the inner volume of the housing and a noise attenuating material placed between the at least one perforated wall and the inner surface of the housing.

[0012] In this manner, conditions are provided for a compact exhaust assembly capable of obtaining a low transfer of heat from the first exhaust aftertreatment unit to an external surface of the housing, while having conditions for attenuating exhaust noise in an efficient manner.

[0013] That is, since the first exhaust aftertreatment unit is arranged inside the inner volume of the housing, a space-efficient solution is provided in which an outer surface of the first exhaust aftertreatment unit can be utilized for reflecting sound/pressure waves inside the inner volume of the housing to thereby attenuate exhaust noise inside the inner volume of the housing. In addition, since the exhaust assembly comprises the at least one perforated wall arranged inside the inner volume of the housing and the noise attenuating material placed between the at least one perforated wall and the inner surface of the housing, it can be ensured that sound/-pressure waves inside the inner volume of the housing are attenuated in an efficient manner. Accordingly, due to these features, conditions are provided for a compact exhaust assembly capable of attenuating exhaust noise in an efficient manner.

[0014] Furthermore, since the first exhaust aftertreatment unit is arranged inside the inner volume of the housing, a low transfer of heat can be ensured from the first exhaust aftertreatment unit to external surfaces of the housing. This effect is further supplemented by the fact that the exhaust assembly comprises the at least one perforated wall arranged inside the inner volume of the housing and the noise attenuating material placed between the at least one perforated wall and the inner surface of the housing, because the noise attenuating material can provide a thermal insulating effect reducing the heat transfer from the inner volume of the housing to the external surface of the housing.

[0015] Moreover, since a low transfer of heat can be ensured from the first exhaust aftertreatment unit to external surfaces of the housing, conditions are provided for increasing the internal temperature of the first exhaust aftertreatment unit in a quicker manner after start-up of a combustion engine comprising the exhaust assembly, so as to reduce the time needed for reaching an operational temperature threshold of the first exhaust aftertreatment unit. In addition, conditions are provided for maintaining the internal temperature of the first exhaust aftertreatment unit above the operational temperature threshold in more various operational conditions of an engine or a vehicle comprising the exhaust assembly.

[0016] Furthermore, since conditions are provided for a compact exhaust assembly capable of obtaining a low heat transfer to an outer surface of the housing, an exhaust assembly is provided capable of alleviating packing problems in vehicles.

[0017] In addition, an exhaust assembly is provided capable of reducing the need for further arrangements such as external insulation, heat shields, as well as one or more further additional boxes, such as a stack or secondary silencer, in an exhaust system comprising the exhaust assembly. Moreover, an exhaust assembly is provided capable of reducing the need for providing large void spaces around the exhaust assembly.

[0018] In addition, due to the features of the exhaust assembly, an exhaust assembly is provided capable of reducing assembling costs of vehicles comprising the exhaust assembly.

[0019] Accordingly, an exhaust assembly is provided overcoming, or at least alleviating, at least some of the above-mentioned problems and drawbacks. As a result, the above-mentioned object is achieved.

[0020] Optionally, the first exhaust aftertreatment unit comprises an outer shell forming a delimiting surface of the inner volume of the housing. Thereby, it is ensured that the outer shell of the first exhaust aftertreatment unit can be utilized for reflecting sound/pressure waves inside the inner volume of the housing to thereby attenuate exhaust noise inside the inner volume of the housing in an efficient manner.

[0021] Optionally, the first exhaust aftertreatment unit is a catalytic converter. Thereby, an exhaust assembly is provided having conditions for reducing a proportion of harmful substances flowing through the exhaust assembly while ensuring a low transfer of heat from the catalytic converter to an external surface of the housing.

[0022] In addition, conditions are provided for increasing the internal temperature of the catalytic converter in a quicker manner after start-up of a combustion engine comprising the exhaust assembly. In this manner, the time needed for reaching an operational temperature threshold of the catalytic converter can be reduced. In addition, conditions are provided for maintaining the internal temperature of the catalytic converter above the operational temperature threshold in more various operational conditions of an engine or a vehicle comprising the exhaust assembly.

[0023] Optionally, at least part of the first exhaust aftertreatment unit is enclosed by the noise attenuating material. Thereby, it can be ensured that exhaust noise is attenuated in an efficient manner inside the inner volume of the housing. In addition, a low transfer of heat can be further ensured between the first exhaust aftertreatment unit and an external surface of the housing. This is because the noise attenuating material can provide a thermal insulating effect.

[0024] In addition, conditions are provided for increasing the internal temperature of the first exhaust aftertreatment unit in a quicker manner after start-up of a combustion engine comprising the exhaust assembly. In this manner, the time needed for reaching an operational temperature threshold of the first exhaust aftertreatment unit can be reduced. In addition, conditions are provided for maintaining the internal temperature of the first exhaust aftertreatment unit above the operational temperature threshold in more various operational conditions of an engine or a vehicle comprising the exhaust assembly.

[0025] Optionally, the exhaust assembly comprises a first perforated wall arranged inside the inner volume of the housing and a noise attenuating material placed between the first perforated wall and a first portion of the inner surface of the housing and a second perforated wall arranged inside the inner volume of the housing and a noise attenuating material placed between the second perforated wall and a second portion of the inner surface of the housing. Thereby, it can be further ensured that exhaust noise is attenuated in an efficient manner inside the inner volume of the housing. In addition, a low transfer of heat can be further ensured to external surfaces of the housing.

[0026] Optionally, the second portion of the inner surface is opposite to the first portion of the inner surface. Thereby, it can be further ensured that exhaust noise is attenuated in an efficient manner inside the inner volume of the housing. This is because the noise attenuating material can provide a dissipative effect to absorb exhaust noise whereas each of the first and second perforated walls can reflect exhaust noise in directions toward each other so as to provide a reactive muffler effect. In addition, a low transfer of heat can be further ensured to at least two opposite external surfaces of the housing.

[0027] Optionally, the outlet of the first exhaust aftertreatment unit is fluidly connected to the inner volume of the housing via an aperture located in a sub-volume of the inner volume, and wherein the sub-volume is free from noise attenuating material. Thereby, a low flow resistance can be ensured through the exhaust assembly to provide a low backpressure in an exhaust system upstream of the exhaust assembly.

[0028] Optionally, the sub-volume is delimited by each of the first and second perforated walls. Thereby, it can be further ensured that exhaust noise is attenuated in an efficient manner inside the inner volume of the housing. This is because the reflection of exhaust noise against the first and second perforated walls can provide a reactive muffler effect inside the sub-volume while the noise attenuating material placed between the first and second perforated walls and the inner surface of the housing can provide a dissipative effect to absorb the exhaust noise.

[0029] Optionally, the exhaust assembly comprises a second exhaust aftertreatment unit arranged inside the inner volume of the housing, and wherein the second exhaust aftertreatment unit comprises an inlet fluidly connected to the outlet of the first exhaust aftertreatment unit and an outlet fluidly connected to the inner volume of the housing. Thereby, conditions are provided for a compact exhaust assembly capable of obtaining a low transfer of heat from the second exhaust aftertreatment unit to an external surface of the housing, while having conditions for attenuating exhaust noise in an efficient manner.

[0030] That is, since the second exhaust aftertreatment unit is arranged inside the inner volume of the housing, a space-efficient solution is provided in which an outer surface of the second exhaust aftertreatment unit can be utilized for reflecting sound/pressure waves inside the inner volume of the housing to thereby attenuate exhaust noise inside the inner volume of the housing. Accordingly, due to these features, conditions are provided for a compact exhaust assembly capable of attenuating exhaust noise in an efficient manner.

[0031] Furthermore, since the second exhaust aftertreatment unit is arranged inside the inner volume of the housing, a low transfer of heat can be ensured from the second exhaust aftertreatment unit to an external surface of the housing. As a further result, conditions are provided for increasing the internal temperature of the second exhaust aftertreatment unit in a quicker manner after start-up of a combustion engine comprising the exhaust assembly, so as to reduce the time needed for reaching an operational temperature threshold of the second exhaust aftertreatment unit. In addition, conditions are provided for maintaining the internal temperature of the second exhaust aftertreatment above the operational temperature threshold in more various operational conditions of an engine or a vehicle comprising the exhaust assembly.

[0032] Moreover, since conditions are provided for a compact exhaust assembly capable of obtaining a low heat transfer to an outer surface of the housing, an exhaust assembly is provided capable of alleviating packing problems in vehicles. In addition, since the second exhaust aftertreatment unit is arranged inside the inner volume of the housing, an exhaust assembly is provided capable of further alleviating packing problems in vehicles, and further reducing assembling costs of vehicles comprising the exhaust assembly.

[0033] Optionally, the second exhaust aftertreatment unit is a particulate filter. Thereby, an exhaust assembly is provided having conditions for reducing a proportion of harmful substances flowing through the exhaust assembly while having conditions for attenuating exhaust noise in an efficient manner and ensuring a low transfer of heat from the particulate filter to an external surface of the housing.

[0034] Optionally, at least part of the second exhaust aftertreatment unit is enclosed by the noise attenuating material. Thereby, it can be ensured that exhaust noise is attenuated in an efficient manner inside the inner volume of the housing. In addition, a low transfer of heat can be further ensured between the second exhaust aftertreatment unit and an external surface of the housing. This is because the noise attenuating material can provide a thermal insulating effect.

[0035] Moreover, in embodiments in which the second exhaust aftertreatment unit is a catalytic converter, conditions are provided for increasing the internal temperature of the catalytic converter in a quicker manner after start-up of a combustion engine comprising the exhaust assembly. In this manner, the time needed for reaching an operational temperature threshold of the catalytic converter can be reduced. In addition, conditions are provided for maintaining the internal temperature of the catalytic converter above the operational temperature threshold in more various operational conditions of an engine or a vehicle comprising the exhaust assembly.

[0036] Optionally, the noise attenuating material comprises acoustic wool. Thereby, it can be further ensured that exhaust noise is attenuated in an efficient manner inside the inner volume of the housing due to the dissipative effect of the acoustic wool. In addition, due to the thermal insulating effect of the acoustic wool, a low transfer of heat to an external surface of the housing can be further ensured.

[0037] The acoustic wool may be comprised of fine, long, fibres of a material with high thermal resistance such as glass, mineral, ceramic, or basalt. The acoustic wool may, as an alternative, or in addition, include synthetic fibres and/or metal particles to improve the sound absorption capabilities of the acoustic wool. The fibres of the acoustic wool may be treated with binders and/or fillers to enhance the structural integrity of the acoustic wool to ensure that the acoustic wool maintain the shape and effectiveness under the thermal cycling typical in an exhaust system.

[0038] Optionally, the exhaust assembly comprises at least one separating wall arranged inside the inner volume of the housing and a thermally insulating material placed between the at least one separating wall and the inner surface of the housing. Thereby, a low transfer of heat can be further ensured from the inner volume of the housing to external surfaces of the housing. In addition, it can be further ensured that exhaust noise is attenuated in an efficient manner inside the inner volume of the housing. This is because the at least one separating wall arranged inside the inner volume of the housing can be utilized to reflect exhaust noise to provide a reactive muffler effect inside the inner volume of the housing while the thermally insulating material placed between the at least one separating wall and the inner surface of the housing can provide a dissipative effect to reduce the transfer of noise from the inner volume of the housing to the environment outside of the housing.

[0039] Optionally, the thermally insulating material is placed in a sub-volume delimited by the least one separating wall and the inner surface of the housing, and wherein the sub-volume is fluidly connected to a sub-volume in which the noise attenuating material is placed. Thereby, it can be further ensured that the exhaust noise is attenuated in an efficient manner inside the inner volume of the housing and that a low transfer of noise is provided from the inner volume of the housing to the environment outside of the housing. This is because the fluid connection between the sub-volume in which the thermally insulating material is placed and the sub-volume in which the noise attenuating material is placed can ensure that exhaust noise is dampened by a dissipative effect as well as a reactive effect between the two different sub-volumes.

[0040] Optionally, the thermally insulating material comprises thermal wool. Thereby, a low transfer of heat to external surfaces of the housing can be further ensured. In addition, it can be further ensured that exhaust noise is attenuated in an efficient manner inside the inner volume of the housing to provide a low transfer of noise to the environment outside of the housing due to the dissipative effect of the thermal wool.

[0041] The thermal wool may be comprised of fine, long, fibres of a material with high thermal resistance such as glass, mineral, ceramic, or basalt. The thermal wool may also comprise synthetic fibres and/or metal particles. The fibres of the thermal wool may also be treated with binders and/or fillers to enhance the structural integrity of the thermal wool to ensure that the thermal wool maintain the shape and effectiveness under the thermal cycling typical in an exhaust system.

[0042] As understood from the above described, each of the thermal wool and the acoustic wool referred to herein may provide a dissipative noise attenuating effect as well as a thermal insulating effect. Moreover, the thermal wool, as referred to herein, may at least in part be composed of the same type of material as the acoustic wool referred to herein. However, the thermal wool, as referred to herein, may differ from the acoustic wool by being denser than the acoustic wool. In other words, the fibres of the thermal wool may be more tightly packed than the fibres of the acoustic wool. Moreover, the acoustic wool may be treated with a higher proportion of binders and/or fillers than the thermal wool. In this manner, the acoustic wool can be able to maintain its shape despite the relatively low density of the fibres thereof. According to some embodiments, the thermal wool may lack binders and/or fillers.

[0043] According to a second aspect of the present disclosure, the object is achieved by an internal combustion engine comprising an exhaust assembly according to some embodiments of the present disclosure, wherein the exhaust inlet of the housing is fluidly connected to an exhaust outlet of the internal combustion engine. Since the internal combustion engine comprises an exhaust assembly according to some embodiments, an internal combustion engine is provided overcoming, or at least alleviating, at least some of the above-mentioned problems and drawbacks. As a result, the above-mentioned object is achieved.

[0044] According to a third aspect of the present disclosure, the object is achieved by a vehicle comprising an internal combustion engine according to some embodiments of the present disclosure. Since the vehicle comprises an internal combustion engine according to some embodiments, a vehicle is provided overcoming, or at least alleviating, at least some of the above-mentioned problems and drawbacks. As a result, the above-mentioned object is achieved.

[0045] Optionally, the vehicle is a heavy road vehicle. Thereby, a heavy road vehicle is provided having at least some of the above mentioned advantages.

[0046] Further features of, and advantages with, the present invention will become apparent when studying the appended claims and the following detailed description.

BRIEF DESCRIPTION OF THE DRAWINGS

[0047] Various aspects of the present disclosure, including its particular features and advantages, will be readily understood from the example embodiments discussed in the following detailed description and the accompanying drawings, in which:

Fig. 1 schematically illustrates a vehicle according to some embodiments of the present disclosure,
Fig. 2 schematically illustrates an internal combustion engine of the vehicle illustrated in Fig. 1, and
Fig. 3 schematically illustrates a cross-section of an exhaust assembly of the internal combustion engine illustrated in Fig. 2.

DETAILED DESCRIPTION

[0048] Aspects of the present disclosure will now be described more fully. Like reference signs refer to like elements throughout. Well-known functions or constructions will not necessarily be described in detail for brevity and/or clarity.

[0049] **Fig. 1** schematically illustrates a vehicle 2 according to some embodiments of the present disclosure. According to the illustrated embodiments, the vehicle 2 is a truck, i.e. type of heavy road vehicle. However, according to further embodiments, the vehicle 2, as referred to herein, may be another type of manned or unmanned vehicle for land or water based propulsion such as a lorry, a bus, a construction vehicle, a tractor, a car, a ship, a boat, or the like.

[0050] The vehicle 2 comprises an internal combustion engine 40. According to the illustrated embodiments, the internal combustion engine 40 is configured to provide motive power to the vehicle 2 via wheels 41 of the vehicle 2.

[0051] **Fig. 2** schematically illustrates the internal combustion engine 40 of the vehicle 2 illustrated in Fig. 1. According to the illustrated embodiments, the internal combustion engine 40 is an Otto engine with a spark-ignition device, wherein the Otto engine is configured to run on a gaseous fuel. In Fig. 1, a pressure tank 51 of the vehicle 2 is indicated. The pressure tank 51 is configured to accommodate a gaseous fuel under pressure. The gaseous fuel may also be referred to as fuel gas and may encompass any type of fuel that under ordinary ambient temperature and pressure conditions are gaseous and which can be stored at pressure in the pressure tank 51 and can be combusted in an internal combustion engine 40 to produce useful work. Examples of such gaseous fuels are compressed natural gas (CNG), liquified natural gas (LNG), Liquefied Petroleum Gas (LPG), Hydrogen (H2), Biogas, and Syngas.

[0052] Many gaseous fuels can be derived from renewable sources, such as from renewable biomass.

[0053] According to further embodiments, the internal combustion engine 40, as referred to herein, may another type of Otto engine with a spark-ignition device, wherein the Otto engine may be configured to run on petrol, alcohol, or combinations thereof. Alcohol, such as ethanol, can be derived from renewable biomass. According to embodiments herein, the internal combustion engine 40 is a four-stroke internal combustion engine 40.

[0054] According to still further embodiments, the internal combustion engine 40 may be a diesel engine, i.e. a type of compression ignition engine. The internal combustion engine 40 may thus be configured to operate on diesel or a diesel-like fuel, such as biodiesel, biomass to liquid (BTL), or gas to liquid (GTL) diesel. Diesel-like fuels, such as biodiesel, can be obtained from renewable sources such as vegetable oil which mainly comprises fatty acid methyl esters (FAME). Diesel-like fuels can be produced from many types of oils, such as rapeseed oil (rapeseed methyl ester, RME) and soybean oil (soy methyl ester, SME).

[0055] For reasons of brevity and clarity, the internal combustion engine 40 is in some places herein referred to as the combustion engine 40, or simply the engine 40. According to some embodiments, the combustion engine 40, as referred to herein, may be configured to power another type of unit than a vehicle, such as for example an electric generator.

[0056] According to the illustrated embodiments, the combustion engine 40 comprises a turbocharger 30. As is further explained herein, the turbocharger 30 comprises a turbine unit configured to be driven by exhaust gas from an exhaust outlet 46 of the internal combustion engine 40. Moreover, the combustion engine 40 comprises an exhaust conduit 47 and an exhaust assembly 1, wherein the exhaust conduit 47 fluidly connects an outlet of the turbine unit of the turbocharger 30 to an exhaust inlet of the exhaust assembly 1. The turbocharger 30 further comprises compressor arrangement with a compressor wheel connected to the turbine unit of the turbocharger 30.

[0057] According to the illustrated embodiments, the combustion engine 40 comprises an air filter unit 43 and a charge air cooler 44. The compressor arrangement of the turbocharger 30 is configured to force air from the air filter unit 43 to the air inlet 42 of the engine 40. The charge air cooler 44 is arranged between the compressor arrangement 32 of the turbocharger 30 and the air inlet 42 of the combustion engine 40. The charge air cooler 44 is configured to cool the compressed air before the air is conducted to the air inlet 42. In this manner, the power output and fuel efficiency of the combustion engine 40 can be improved.

[0058] The internal combustion engine 40 comprises an air inlet assembly 48 forming a flow path for air between the air filter unit 43 and a compressor inlet of the compressor of the turbocharger 30. In other words, the air inlet assembly 48 is configured to conduct air from the air filter unit 43 to the compressor of the turbocharger 30.

[0059] According to further embodiments, the combustion engine 40 may lack a turbocharger 30. According to such embodiments, the exhaust inlet of the exhaust assembly 1, referred to above, may be directly connected to the exhaust outlet 46 of the combustion engine 40 via one or more exhaust conduits.

[0060] **Fig. 3** schematically illustrates a cross-section of the exhaust assembly 1 of the internal combustion engine 40 illustrated in Fig. 2. In Fig. 3, the exhaust inlet 11 of the exhaust assembly 1 is indicated. Below, simultaneous reference is made to Fig. 1 - Fig. 3, if not indicated otherwise.

[0061] According to the illustrated embodiments, the exhaust inlet 11 of the housing 3 is fluidly connected to the exhaust outlet 46 of the internal combustion engine 40 via the turbine unit of the turbocharger 30. However, according to further embodiments, the exhaust inlet of the exhaust assembly 1 may be directly connected to the exhaust outlet 46 of a combustion engine 40 via one or more exhaust conduits or may be fluidly connected to the exhaust outlet 46 of a combustion engine 40 via one or more other types of arrangements or systems than a turbine unit of a turbocharger.

[0062] The exhaust assembly 1 comprises a housing 3 comprising the exhaust inlet 11 and exhaust outlet 12. The exhaust outlet 12 of the housing 3 may be fluidly connected to the surroundings via further piping. The housing 3 comprises an inner surface 3' delimiting an inner volume V of the housing 3. The housing 3 may be formed by stainless steel.

[0063] Moreover, the exhaust assembly 1 comprises a first exhaust aftertreatment unit u1 arranged inside the inner volume V. According to the illustrated embodiments, the first exhaust aftertreatment unit u1 is a catalytic converter, i.e., an emissions control device capable of converting toxic gases and pollutants in exhaust gas from the internal combustion engine 40 into less-toxic pollutants by catalysing a redox reaction. The first exhaust aftertreatment unit u1 may comprise of a core made of a ceramic honeycomb or metallic substrate coated with catalysts, including one or more of platinum, palladium, and rhodium. According to the illustrated embodiments, the first exhaust aftertreatment unit u1 comprises an outer shell 5, wherein the substrate is arranged inside the outer shall 5. The catalytic reaction occurs as the exhaust gases pass over the substrate, facilitating the transformation of carbon monoxide, unburned hydrocarbons, and nitrogen oxides into carbon dioxide, nitrogen, and water vapor. Moreover, according to the illustrated embodiments, the outer shell 5 forms a delimiting surface of the inner volume V of the housing 3. The outer shell 5 may comprise stainless steel designed to withstand high temperatures.

[0064] According to further embodiments, the first exhaust aftertreatment unit u1, as referred to herein, may be another type of exhaust aftertreatment unit, such as a selective catalytic reduction (SCR) unit, an ammonia slip catalyst, a particulate filter, a Lean NOx Trap, a diesel oxidation catalyst, a methane oxidation catalyst, an electric heater, or the like.

[0065] A Selective Catalytic Reduction (SCR) system is an active emissions control technology that injects a reductant agent, such as a urea-based solution, into the exhaust stream of a combustion engine. The reductant agent vaporizes and decomposes to form ammonia and carbon dioxide. Then, in the presence of the selective catalytic reduction (SCR) unit, the ammonia reacts with nitrogen oxides (NOx) to convert them into harmless nitrogen (N2) and water (H2O). This reaction occurs high temperatures effectively reducing the level of NOx emissions released into the atmosphere and allowing the vehicle to meet stringent environmental standards.

[0066] An ammonia slip catalyst is a type of exhaust aftertreatment technology used to decompose excess ammonia in the exhaust gases. This ammonia, referred to as "slip" because it 'slips' through the selective catalytic reduction (SCR) system without reacting to reduce nitrogen oxides (NOx), can be harmful if released into the atmosphere. The catalyst functions by breaking down the ammonia into nitrogen and water before the exhaust gases are emitted from the tailpipe. It is typically used in conjunction with SCR systems in compression ignition engines, such as diesel engines, to ensure that emissions standards are met and to prevent the release of unreacted ammonia.

[0067] A particulate filter is a device designed to remove particulate matter or soot from the exhaust gas of a combustion engine. It traps the particulate pollutants as the exhaust flow passes through it. A particulate filter typically uses a substrate made of a ceramic material that provides a large filtration surface. Periodically, the accumulated soot is burned off at high temperatures in a regeneration process, which can be active or passive, to clean the filter and prevent clogging. This process ensures that the particulate filter maintains its efficacy and allows vehicles to meet specific emissions regulations.

[0068] Historically, particulate filters were more commonly associated with diesel engines due to the higher levels of particulate matter in diesel exhaust. Such particulate filters are commonly known as a diesel particulate filters (DPF). However, with stricter emission regulations and the realization that Otto engines, especially those with direct injection technology, also produce significant particulate emissions, the use of particulate filters for these engines has become more common. Such particulate filters can be referred to as gasoline particulate filters (GPFs) and work similarly to diesel particulate filters (DPFs), capturing and periodically burning off particulate matter to reduce emissions.

[0069] A Lean NOx Trap (LNT), also known as a NOx adsorber, is an exhaust aftertreatment system designed to reduce nitrogen oxide emissions from diesel and Otto engines that operate on a lean air-to-fuel ratio. The Lean NOx Trap works by adsorbing NOx onto a catalyst surface during lean engine operation. Once the surface is saturated, the engine runs under a temporary rich condition, which creates a reducing environment. This environment allows the adsorbed NOx to be converted into nitrogen (N_2), carbon dioxide (CO_2), and water (H_2O) before being released into the atmosphere. The Lean NOx Trap is particularly suitable for vehicles that are not able to maintain the high temperatures required for efficient selective catalytic reduction (SCR) system operation.

[0070] A diesel oxidation catalyst (DOC) is a component used for reducing emissions from compression ignition engines, such as diesel engines, converting harmful carbon monoxide (CO) and hydrocarbons (HC) in the exhaust into carbon dioxide (CO_2) and water (H_2O). It features a catalyst, often made of precious metals like platinum, coated on a ceramic or metal substrate. This catalyst facilitates oxidation of pollutants at lower temperatures, effectively reducing unburnt hydrocarbons and carbon monoxide emissions. A diesel oxidation catalyst (DOC) may work in conjunction with other emission control devices to minimize diesel engine pollution.

[0071] A methane oxidation catalyst for engines is configured to reduce methane emissions primarily from natural gas-powered engines. It catalyses the conversion of methane (CH_4), a significant greenhouse gas, into less harmful substances, carbon dioxide (CO_2) and water (H_2O). The methane oxidation catalyst typically uses metals like palladium or platinum on a ceramic or metal substrate, enabling the oxidation of methane at comparatively lower temperatures.

[0072] An electric heater (e-heater) in automotive applications serves to enhance emission control systems, especially in cold conditions. It's used primarily in hybrid and electric vehicles, where traditional methods of heating through engine waste heat are insufficient. The e-heater quickly brings a catalytic converter and other emission control components to optimal operating temperatures, ensuring efficient functioning from the start of the vehicle. This rapid heating can reduce harmful emissions like hydrocarbons, carbon monoxide, and nitrogen oxides, which tend to be higher during cold starts.

[0073] As can be seen in Fig. 3, the first exhaust aftertreatment unit u1 comprises an inlet u1' fluidly connected to the exhaust inlet 11 of the housing 3. In other words, the inlet u1' of the first exhaust aftertreatment unit u1 is configured to receive exhaust gas flowing into the exhaust assembly 1 via the exhaust inlet 11 of the housing 3. According to the illustrated embodiments, the inlet u1' of the first exhaust aftertreatment unit u1 is arranged at the region of the exhaust inlet 11 of the housing 3. According to further embodiments, the inlet u1' of the first exhaust aftertreatment unit u1 may be fluidly connected to the exhaust inlet 11 of the housing 3 via piping arranged inside the inner volume V of the housing 3.

[0074] As can be seen in Fig. 3, the first exhaust aftertreatment unit u1 further comprises an outlet u1". The outlet u1" of the first exhaust aftertreatment unit u1 is fluidly connected to the inner volume V of the housing 3. According to the illustrated embodiments, the outlet u1" of the first exhaust aftertreatment unit u1 is fluidly connected to the inner volume V of the housing 3 via an outlet u2" of a second exhaust aftertreatment unit u2. However, according to further embodiments, the outlet u1" of the first exhaust aftertreatment unit u1 may be fluidly connected to the inner volume V of the housing 3 in another manner, such as via a direct connection or via further piping.

[0075] Moreover, the exhaust assembly 1 comprises at least one perforated wall w1, w2 arranged inside the inner volume V of the housing 3 and a noise attenuating material 9, 9' placed between the at least one perforated wall w1, w2 and the inner surface 3' of the housing 3.

[0076] In this manner, conditions are provided for a compact exhaust assembly 1 capable of obtaining a low transfer of heat from the first exhaust aftertreatment unit u1 to an external surface 25 of the housing 3, while having conditions for attenuating exhaust noise in an efficient manner.

[0077] That is, since the first exhaust aftertreatment unit u1 is arranged inside the inner volume V of the housing 3, a space-efficient solution is provided in which an outer surface of the first exhaust aftertreatment unit u1, i.e., an outer surface of the outer shell 5 of the first exhaust aftertreatment unit u1, can be utilized for reflecting sound/pressure waves inside the inner volume V of the housing 3 to thereby attenuate exhaust noise inside the inner volume V of the housing 3. In addition, since the exhaust assembly 1 comprises the at least one perforated wall w1, w2 arranged inside the inner volume V of the housing 3 and the noise attenuating material 9, 9' placed between the at least one perforated wall w1, w2 and the inner surface of the housing 3, it can be ensured that sound/pressure waves inside the inner volume V of the housing 3 are attenuated in an efficient manner. Accordingly, due to these features, conditions are provided for a compact exhaust assembly 1 capable of attenuating exhaust noise in an efficient manner.

[0078] Furthermore, since the first exhaust aftertreatment unit u1 is arranged inside the inner volume V of the housing 3, a low transfer of heat can be ensured from the first exhaust aftertreatment unit u1 to external surfaces 25 of the housing 3. This effect is further supplemented by the fact that the exhaust assembly 1 comprises the at least one perforated wall w1, w2 arranged inside the inner volume V of the housing 3 and the noise attenuating material 9, 9' placed between the at least one perforated wall w1, w2 and the inner surface of the housing 3, because the noise attenuating material 9, 9' can provide a thermal insulating effect reducing the heat transfer from the inner volume V of the housing 3 to the external surface 25 of the housing 3.

[0079] Moreover, since a low transfer of heat can be ensured from the first exhaust aftertreatment unit u1 to external surfaces 25 of the housing 3, conditions are provided for increasing the internal temperature of the first exhaust aftertreatment unit u1 in a quicker manner after start-up of a combustion engine comprising the exhaust assembly 1, so as to reduce the time needed for reaching an operational temperature threshold of the first exhaust aftertreatment unit u1. In addition, conditions are provided for maintaining the internal temperature of the first exhaust aftertreatment unit u1 above the operational temperature threshold in more various operational conditions of a combustion engine 40 or a vehicle 2 comprising the exhaust assembly 1.

[0080] Furthermore, since conditions are provided for a compact exhaust assembly 1 capable of obtaining a low heat transfer to an outer surface of the housing 3, an exhaust assembly 1 is provided capable of alleviating packing problems in vehicles 2. In addition, an exhaust assembly 1 is provided capable of reducing the need for further arrangements such as external insulation, heat shields, as well as one or more further additional boxes, such as a stack or secondary silencer, in an exhaust system comprising the exhaust assembly 1. Moreover, an exhaust assembly 1 is provided capable of reducing the need for providing large void spaces around the exhaust assembly 1.

[0081] According to the illustrated embodiments, the exhaust assembly 1 comprises a first perforated wall w1 arranged inside the inner volume V of the housing 3 and a noise attenuating material 9 placed between the first perforated wall w1 and a first portion 13 of the inner surface 3' of the housing 3. Moreover, according to the illustrated embodiments, the exhaust assembly 1 comprises a second perforated wall w2 arranged inside the inner volume V of the housing 3 and a noise attenuating material 9' placed between the second perforated wall w2 and a second portion 13' of the inner surface 3' of the housing 3. As seen in Fig. 3, according to the illustrated embodiments, the second portion 13' of the inner surface 3' is opposite to the first portion 13 of the inner surface 3'. In other words, according to the illustrated embodiments, the second portion 13' of the inner surface 3' faces the first portion 13 of the inner surface 3'.

[0082] Thereby, it can be further ensured that exhaust noise is attenuated in an efficient manner inside the inner volume V of the housing 3. This is because the noise attenuating material can provide a dissipative effect to absorb exhaust noise whereas each of the first and second perforated walls w1, w2 can reflect exhaust noise in directions toward each other so as to provide a reactive muffler effect. In addition, a low transfer of heat can be further ensured to at least two opposite external surfaces 25 of the housing 3.

[0083] The noise attenuating material 9' placed between the second perforated wall w2 and the second portion 13' of the inner surface 3' of the housing 3 may be of similar type and composition as the noise attenuating material 9 placed between the first perforated wall w1 and the first portion 13 of the inner surface 3' of the housing 3. The noise attenuating material 9, 9' may comprise acoustic wool. The acoustic wool may be comprised of fine, long, fibres of a material with high thermal resistance such as glass, mineral, ceramic, basalt, or a synthetic material. The noise attenuating material 9, 9', as referred to herein, may also be referred to as an acoustic insulation material, a sound dampening material, or the like.

[0084] As can be seen in the schematic illustration of Fig. 3, according to the illustrated embodiments, at least part of the first exhaust aftertreatment unit u1 is enclosed by the noise attenuating material 9. Thereby, it can be ensured that exhaust noise is attenuated in an efficient manner inside the inner volume V of the housing 3. In addition, a low transfer of heat can be further ensured between the first exhaust aftertreatment unit u1 and an external surface 25 of the housing 3. This is because the noise attenuating material 9 can provide a thermal insulating effect between the first exhaust aftertreatment unit u1 and the external surface 25 of the housing 3.

[0085] According to the illustrated embodiments, the exhaust assembly 1 comprises a separating wall w3 arranged inside the inner volume V of the housing 3 and a thermally insulating material 19 placed between the separating wall w3 and the inner surface 3' of the housing 3.

[0086] Thereby, a low transfer of heat can be further ensured from the inner volume V of the housing 3 to external surfaces 25 of the housing 3. In addition, it can be further ensured that exhaust noise is attenuated in an efficient manner inside the inner volume V of the housing 3. This is because the at least one separating wall w3 arranged inside the inner volume V of the housing 3 can be utilized to reflect exhaust noise to provide a reactive muffler effect inside the inner volume V of the housing 3 while the thermally insulating material placed between the separating wall w3 and the inner surface 3' of the housing 3 can provide a dissipative effect to reduce the transfer of noise from the inner volume V of the housing 3 to the environment outside of the housing 3.

[0087] The separating wall w3 may be a solid, non-perforated wall. However, according to further embodiments, the separating wall w3, as referred to herein, may be a perforated separating wall. The wording perforated, as used herein, means that the wall referred to comprises a number of through holes distributed across the wall.

[0088] The thermally insulating material 19 may comprise thermal wool. The thermal wool, as referred to herein, may at least in part be composed of the same type of material as the acoustic wool referred to herein. However, the thermal wool, as referred to herein, may differ from the acoustic wool by being denser than the acoustic wool.

[0089] According to the illustrated embodiments, the exhaust assembly 1 comprises one separating wall w3, wherein the separating wall w3 fully enclose a sub-volume V3 of the inner volume V of the housing 3 in a plane perpendicular to the plane of the cross section of Fig. 3. In other words, according to the illustrated embodiments, the separating wall w3 is bent or shaped around the sub-volume V3 to fully enclose the sub-volume V3 of the inner volume V of the housing 3 in the plane perpendicular to the plane of the cross section of Fig. 3.

[0090] The sub-volume V3 is moreover delimited by each of the first and second perforated walls w1, w2. As seen in Fig. 3, the sub-volume V3 is free from noise attenuating material 9, 9' and thermally insulating material 19.

[0091] The housing 3 of the exhaust assembly 1 may have a circular, oval, square, a rectangular shape in the plane perpendicular to the plane of the cross section of Fig. 3, or may have a combination of these shapes. The shape of the separating wall w3 may follow the shape of the housing 3 of the exhaust assembly 1 in the plane perpendicular to the plane of the cross section of Fig. 3 to obtain an at least substantially equal distance between the inner surface 3' of the housing 3 and the separating wall w3 as measured in the plane perpendicular to the plane of the cross section of Fig. 3.

[0092] However, according to further embodiments, the exhaust assembly 1 may comprise two or more separating walls arranged inside the inner volume V of the housing 3 and a thermally insulating material placed between each separating wall and the inner surface 3' of the housing 3. Also in such embodiments, the sub-volume v3 may be fully enclosed by separating walls in the plane perpendicular to the plane of the cross section of Fig. 3 according to the above described.

[0093] As mentioned, according to the illustrated embodiments, the exhaust assembly 1 comprises a second exhaust aftertreatment unit u2 arranged inside the inner volume V of the housing 3. The second exhaust aftertreatment unit u2 comprises an inlet u2' fluidly connected to the outlet u1" of the first exhaust aftertreatment unit u1 and an outlet u2" fluidly connected to the inner volume V of the housing 3. In more detail, according to the illustrated embodiments, the outlet u1" of the first exhaust aftertreatment unit u1 is fluidly connected to the inlet u2' of the second exhaust aftertreatment unit u2 via piping 17 of the exhaust assembly 1.

[0094] According to the illustrated embodiments, a portion of the piping 17 is arranged outside of the inner volume V of the housing 3. However, according to further embodiments, the piping 17 connecting the outlet u1" of the first exhaust aftertreatment unit u1 to the inlet u2' of the second exhaust aftertreatment unit u2 may be fully contained within the inner volume V of the housing 3.

[0095] As indicated above, according to the illustrated embodiments, the outlet u1" of the first exhaust aftertreatment unit u1 fluidly connected to the inner volume V of the housing 3 via the outlet u2" of the second exhaust aftertreatment unit u2. Moreover, as seen in the schematic illustration of Fig. 3, according to the illustrated embodiments, the outlet u2" of the second exhaust aftertreatment unit u2 is placed in the sub-volume V3 being free from noise attenuating material 9, 9' and thermally insulating material 19. In other words, the outlet u1" of the first exhaust aftertreatment unit u1 is fluidly connected to the inner volume V of the housing 3 via an aperture 15 located in a sub-volume V3 of the inner volume V of the housing 3, and wherein the sub-volume V3 is free from noise attenuating material 9, 9', as well as is free from thermally insulating material 19. Thereby, a low flow resistance can be ensured through the exhaust assembly 1 to provide a low backpressure in an exhaust system upstream of the exhaust assembly 1 while ensuring an efficient attenuation of exhaust noise inside the inner volume V of the housing 3 and a low transfer of heat to external surfaces 25 of the housing 3.

[0096] According to the illustrated embodiments, the second exhaust aftertreatment unit u2 is a particulate filter. However, according to further embodiments, the second exhaust aftertreatment unit u2, as referred to herein, may be another type of exhaust aftertreatment unit, such as a catalytic converter, a selective catalytic reduction (SCR) unit, an ammonia slip catalyst, a Lean NOx Trap, a diesel oxidation catalyst, a methane oxidation catalyst, an electric heater, or the like. Moreover, according to some embodiments, one or both of the first and second exhaust aftertreatment units u1, u2 may comprise a combination of two or more exhaust aftertreatment units of different type, such as a combination of two or more exhaust aftertreatment units each being of a type according to the examples above.

[0097] Moreover, according to some embodiments, the one or both of the first and second exhaust aftertreatment units u1, u2 may comprise, or may be comprised of, an exhaust additive dosing unit configured to inject an exhaust additive, such as an aqueous urea solution, into the stream of exhaust gas through the exhaust assembly 1.

[0098] Furthermore, according to some embodiments, the exhaust assembly 1 may lack the second exhaust aftertreatment unit u2 and may only comprise the first exhaust aftertreatment unit u1 as referred to herein.

[0099] As understood from the above described, according to the illustrated embodiments, the thermally insulating material 19 is placed in a sub-volume V4 delimited by the separating wall w3 and the inner surface 3' of the housing 3. According to the illustrated embodiments, the sub-volume V4 is fluidly connected to a sub-volume V1, V2 in which the noise attenuating material 9, 9' is placed.

[0100] That is, the first perforated wall w1 and the inner surface 3' of the housing 3 delimits a first sub-volume V1 in which noise attenuating material 9 is placed. Likewise, the second perforated wall w2 and the inner surface 3' of the housing 3 delimits a second sub-volume V2 in which noise attenuating material 9' is placed. The sub-volume V3, in which the aperture 15 is placed, and which comprises no noise attenuating material 9, 9', nor any thermally insulating material 19, may be referred to as a third sub-volume V3. The sub-volume V4 delimited by the separating wall w3 and the inner surface 3' of the housing 3 may be referred to as a fourth sub-volume V4.

[0101] As understood from the above described, according to the illustrated embodiments, the third sub-volume V3 is fully enclosed by at least one of noise attenuating material 9, 9' and thermally insulating material 19. Thereby, a low transfer of heat can be provided from the inner volume V of the housing 3 to external surfaces 25 of the housing 3. Moreover, exhaust noise can be attenuated in an efficient manner.

[0102] According to the illustrated embodiments, the fourth sub-volume V4 is fluidly connected to the first sub-volume V1 via a first perforated partition wall w4. Likewise, the fourth sub-volume V4 is fluidly connected to the second sub-volume V2 via a second perforated partition wall w5. However, the exhaust assembly 1 may lack each of the first and second partition walls w4, w5. Instead, the noise attenuating material 9 placed in the first sub-volume V1 may be in abutting contact with the thermally insulating material 19 placed in the fourth sub-volume V4. Likewise, the noise attenuating material 9' placed in the second sub-volume V2 may be in abutting contact with the thermally insulating material 19 placed in the fourth sub-volume V4.

[0103] According to the embodiments illustrated in Fig. 3, part of the first exhaust aftertreatment unit u1 is enclosed by the noise attenuating material 9 placed in the first sub-volume V1. Likewise, part of the second exhaust aftertreatment unit u2 is enclosed by the noise attenuating material 9' placed in the second sub-volume V2. However, according to further embodiments, parts of one or both of the first and second exhaust aftertreatment units u1, u2 may be enclosed by noise attenuating material 9, 9' placed in each of the first and second sub-volumes V1, V2.

[0104] The exhaust assembly 1, as referred to herein, may also be referred to as an exhaust arrangement or an exhaust unit. The feature that the first exhaust aftertreatment unit u1 is arranged inside the inner volume V of the housing 3 may mean that the first exhaust aftertreatment unit u1 is fully or partially contained within the inner volume V of the housing 3.

[0105] Likewise, the feature that the second exhaust aftertreatment unit u2 is arranged inside the inner volume V of the housing 3 may mean that the second exhaust aftertreatment unit u2 is fully or partially contained within the inner volume V of the housing 3.

[0106] It is to be understood that the foregoing is illustrative of various example embodiments and that the invention is defined only by the appended independent claims. A person skilled in the art will realize that the example embodiments may be modified, and that different features of the example embodiments may be combined to create embodiments other than those described herein, without departing from the scope of the present invention, as defined by the appended independent claims.

[0107] As used herein, the term "comprising" or "comprises" is open-ended, and includes one or more stated features, elements, steps, components, or functions but does not preclude the presence or addition of one or more other features, elements, steps, components, functions, or groups thereof.

Claims

1. An exhaust assembly (1) for an internal combustion engine (40), wherein the exhaust assembly (1) comprises:

- a housing (3) comprising an exhaust inlet (11), an exhaust outlet (12), and an inner surface (3') delimiting an inner volume (V) of the housing (3), and
- a first exhaust aftertreatment unit (u1) arranged inside the inner volume (V),

wherein the first exhaust aftertreatment unit (u1) comprises an inlet (u1') fluidly connected to the exhaust inlet (11) of the housing (3) and an outlet (u1") fluidly connected to the inner volume (V) of the housing (3), and
wherein the exhaust assembly (1) comprises at least one perforated wall (w1, w2) arranged inside the inner volume (V) of the housing (3) and a noise attenuating material (9, 9') placed between the at least one perforated wall (w1, w2) and the inner surface (3') of the housing (3).

2. The exhaust assembly (1) according to claim 1, wherein the first exhaust aftertreatment unit (u1) comprises an outer shell (5) forming a delimiting surface of the inner volume (V) of the housing (3).

3. The exhaust assembly (1) according to claim 1 or 2, wherein the first exhaust aftertreatment unit (u1) is a catalytic converter.

4. The exhaust assembly (1) according to any one of the preceding claims, wherein at least part of the first exhaust aftertreatment unit (u1) is enclosed by the noise attenuating material (9).

5. The exhaust assembly (1) according to any one of the preceding claims, wherein the exhaust assembly (1) comprises a first perforated wall (w1) arranged inside the inner volume (V) of the housing (3) and a noise attenuating material (9) placed between the first perforated wall (w1) and a first portion (13) of the inner surface (3') of the housing (3), and a second perforated wall (w2) arranged inside the inner volume (V) of the housing (3) and a noise attenuating material (9') placed between the second perforated wall (w2) and a second portion (13') of the inner surface (3') of the housing (3).

6. The exhaust assembly (1) according to claim 5, wherein the second portion (13') of the inner surface (3') is opposite to the first portion (13) of the inner surface (3').

7. The exhaust assembly (1) according to any one of the preceding claims, wherein the outlet (u1") of the first exhaust aftertreatment unit (u1) is fluidly connected to the inner volume (V) of the housing (3) via an aperture (15) located in a sub-volume (V3) of the inner volume (V), and wherein the sub-volume (V3) is free from noise attenuating material (9, 9').

8. The exhaust assembly (1) according to claim 7 and any one of the claims 5 or 6, wherein the sub-volume (V3) is delimited by each of the first and second perforated walls (w1, w2).

9. The exhaust assembly (1) according to any one of the preceding claims, wherein the exhaust assembly (1) comprises a second exhaust aftertreatment unit (u2) arranged inside the inner volume (V) of the housing (3), and wherein the second exhaust aftertreatment unit (u2) comprises an inlet (u2') fluidly connected to the outlet (u1") of the first exhaust aftertreatment unit (u1) and an outlet (u2") fluidly connected to the inner volume (V) of the housing (3).

10. The exhaust assembly (1) according to claim 9, wherein the second exhaust aftertreatment unit (u2) is a particulate filter.

11. The exhaust assembly (1) according to claim 9 or 10, wherein at least part of the second exhaust aftertreatment unit (u2) is enclosed by the noise attenuating material (9').

12. The exhaust assembly (1) according to any one of the preceding claims, wherein the noise attenuating material (9, 9') comprises acoustic wool.

13. The exhaust assembly (1) according to any one of the preceding claims, wherein the exhaust assembly (1) comprises at least one separating wall (w3) arranged inside the inner volume (V) of the housing (3) and a thermally insulating material (19) placed between the at least one separating wall (w3) and the inner surface (3') of the housing (3).

14. The exhaust assembly (1) according to claim 13, wherein the thermally insulating material (19) is placed in a sub-volume (v4) delimited by the least one separating wall (w3) and the inner surface (3') of the housing (3), and wherein the sub-volume (v4) is fluidly connected to a sub-volume (V1, V2) in which the noise attenuating material (9, 9') is placed.

15. The exhaust assembly (1) according to claim 13 or 14, wherein the thermally insulating material (19) comprises thermal wool.

16. An internal combustion engine (40) comprising an exhaust assembly (1) according to any one of the preceding claims, wherein the exhaust inlet (11) of the housing (3) is fluidly connected to an exhaust outlet (46) of the internal combustion engine (40).

17. A vehicle (2) comprising an internal combustion engine (40) according to claim 16.

18. The vehicle (2) according to claim 17, wherein the vehicle (2) is a heavy road vehicle.

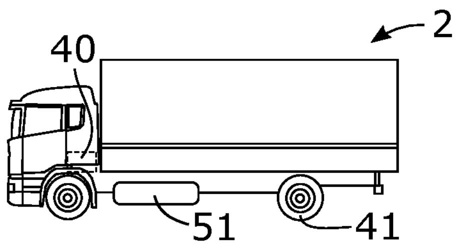

Fig. 1

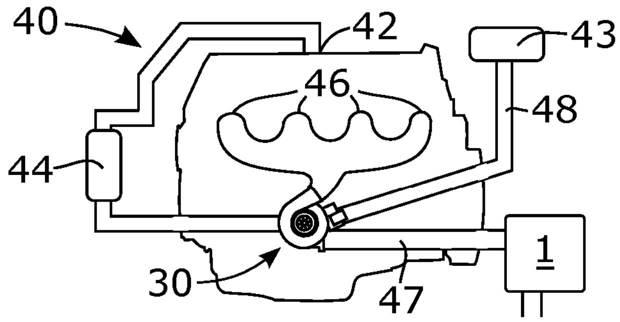

Fig. 2

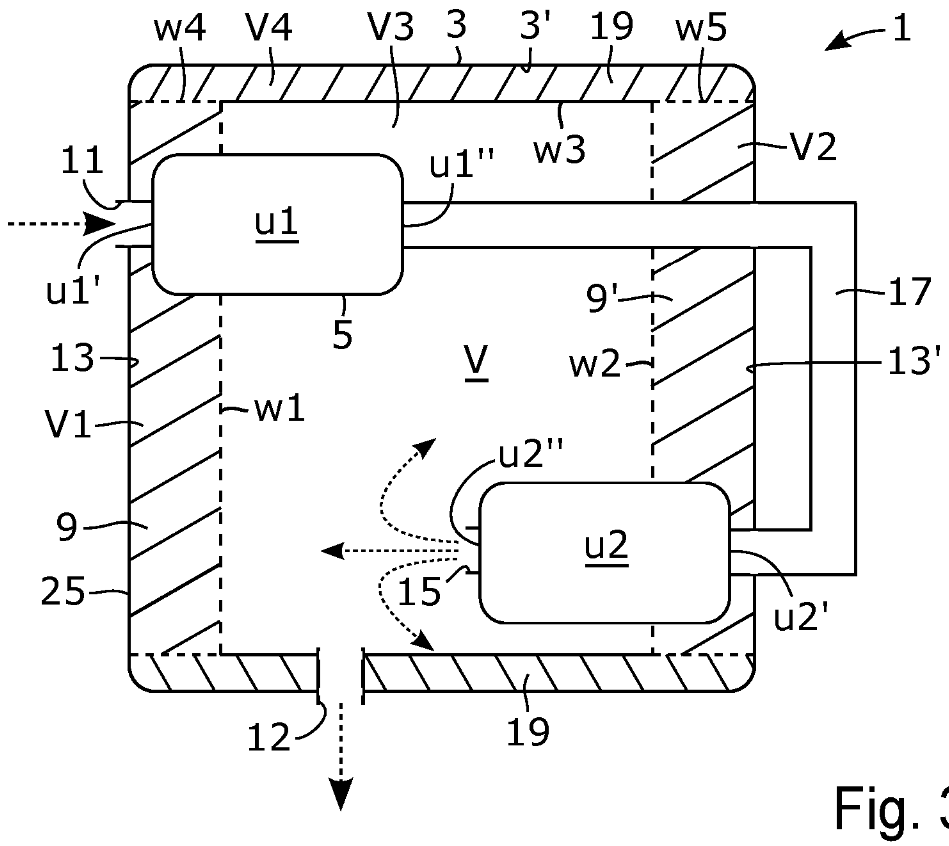

Fig. 3

Europäisches Patentamt
European Patent Office
Office européen des brevets

EUROPEAN SEARCH REPORT

Application Number
EP 23 21 2333

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X A	EP 0 816 648 B1 (ROTH TECHNIK AUSTRIA [AT]; MAN NUTZFAHRZEUGE AG [DE]) 8 August 2001 (2001-08-08) * paragraph [0007] * * paragraph [0011] - paragraph [0012]; figures 1,2 * -----	1-3,7, 12,13, 15-18 4-6, 8-11,14	INV. F01N1/003
X	CN 107 965 383 A (LIU RONG) 27 April 2018 (2018-04-27) * the whole document * -----	1-3,7, 12,16,17	
			TECHNICAL FIELDS SEARCHED (IPC)
			F01N

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
Munich	3 April 2024	Zebst, Marc

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons
....
& : member of the same patent family, corresponding document

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 23 21 2333

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

03-04-2024

Patent document cited in search report		Publication date	Patent family member(s)			Publication date
EP 0816648	B1	08-08-2001	AT	E204055	T1	15-08-2001
			DE	19626980	A1	26-02-1998
			EP	0816648	A1	07-01-1998
CN 107965383	A	27-04-2018	NONE			

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82