



EUROPEAN PATENT APPLICATION

(43) Date of publication:
24.06.2020 Bulletin 2020/26

(51) Int Cl.:
F01N 3/20 (2006.01) **F01N 13/00** (2010.01)
B01F 5/00 (2006.01) **F01N 3/28** (2006.01)

(21) Application number: **18214589.6**

(22) Date of filing: **20.12.2018**

(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 MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME
Designated Validation States:
KH MA MD TN

(72) Inventors:
• **Singh, Samrendra**
Westmont, Illinois 60559 (US)
• **Tamamidis, Panos**
Mount Prospect, Illinois 60056 (US)
• **Demonie, Lode A.**
8840 Staden (BE)

(71) Applicant: **CNH Industrial Belgium NV**
8210 Zedelgem (BE)

(74) Representative: **CNH Industrial IP Department**
Patent Department,
Leon Claeysstraat 3A
8210 Zedelgem (BE)

(54) **EFFICIENT MIXING OF GASES IN AN EXHAUST AFTERTREATMENT SYSTEM**

(57) In an exhaust aftertreatment system (110), an inlet (136) for a selective catalytic reduction (SCR) device (120) having SCR catalysts (132, 134) arranged in tandem within a housing (126). The inlet (136) includes a tube (138) extending in an axial direction and offset from

the longitudinal axis A of the circular or oval cross section housing (126) of the SCR device (120). A scroll section (146), integral with tube (138), provides an opening (148) which imparts a tangential swirl direction to the gas and DEF mixture entering the SCR device (120).

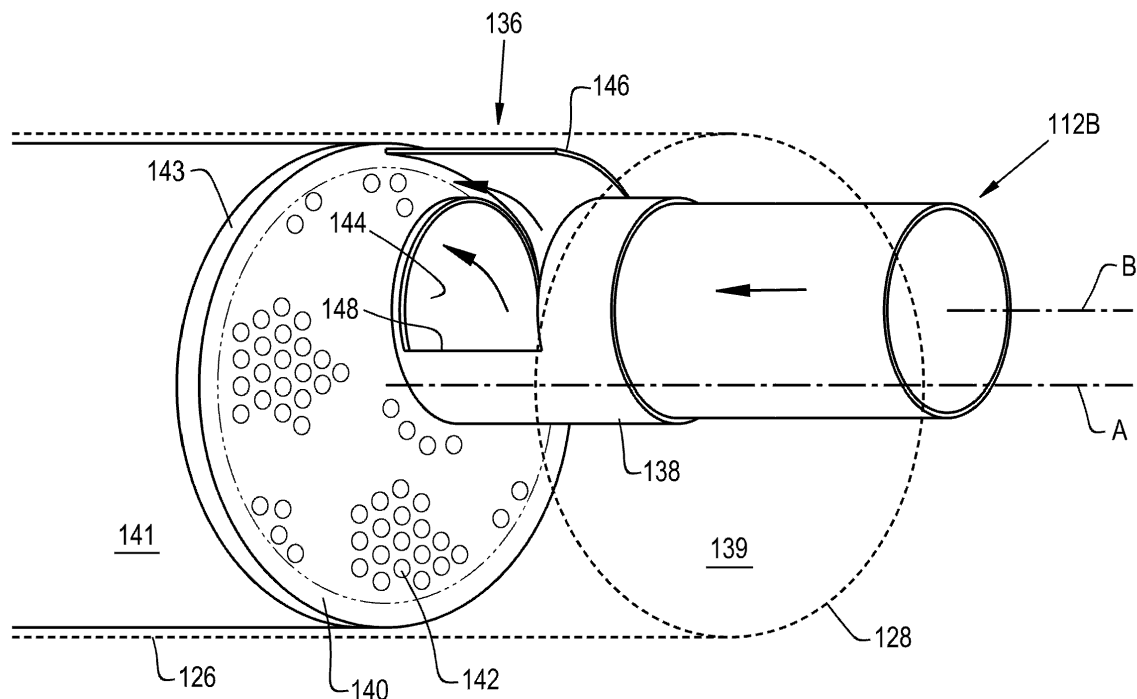


FIG. 2

Description

BACKGROUND OF THE INVENTION

[0001] The present invention relates to exhaust systems for internal combustion engines, and more particularly to a system for decomposing reductant and mixing together reductant and exhaust gas in a selective catalytic reduction (SCR) catalyst device of an exhaust after-treatment system.

[0002] Exhaust aftertreatment systems receive and treat exhaust gas generated from an internal combustion engine such as a diesel engine. Typical exhaust after-treatment systems include any of various devices configured to reduce the level of harmful exhaust emissions present in the exhaust gas. Some exhaust aftertreatment systems for diesel powered internal combustion engines include various devices, such as a diesel oxidation catalyst (DOC), particulate matter filter or diesel particulate filter (DPF), and a selective catalytic reduction (SCR) catalyst device. In some exhaust aftertreatment systems, exhaust gas first passes through the diesel oxidation catalyst, then passes through the diesel particulate filter, and subsequently passes through the SCR catalyst.

[0003] Each of the DOC, DPF, and SCR catalyst devices is configured to perform a particular exhaust emissions treatment operation on the exhaust gas passing through the devices. Generally, the DOC reduces the amount of carbon monoxide and hydrocarbons present in the exhaust gas via oxidation techniques. The DPF filters harmful diesel particulate matter and soot present in the exhaust gas. Finally, the SCR catalyst device reduces the amount of nitrogen oxides (NOx) present in the exhaust gas.

[0004] The SCR catalyst device is configured to reduce NOx into less harmful emissions, such as N₂ and H₂O, in the presence of ammonia (NH₃). Because ammonia is not a natural byproduct of the combustion process, it must be artificially introduced into the exhaust gas prior to the exhaust gas entering the SCR catalyst device. Typically, ammonia is not directly injected into the exhaust gas due to safety considerations associated with the storage of liquid ammonia. Accordingly, conventional systems are designed to inject a urea-water solution, or diesel exhaust fluid (DEF) into the exhaust gas, which is capable of decomposing into ammonia in the presence of the exhaust gas. SCR systems typically include a urea source and a urea injector or doser coupled to the source and positioned upstream of the SCR catalyst device.

[0005] Generally, the decomposition of the urea-water solution into gaseous ammonia occupies three stages. First, urea evaporates or mixes with exhaust gas. Second, the temperature of the exhaust causes a phase change in the urea and decomposition of the urea into isocyanic acid (HNCO) and water. Third, the isocyanic acid reacts with water in a hydrolysis process under specific pressure and temperature concentrations to decompose into ammonia and carbon dioxide (CO₂). The am-

monia is then introduced at or near the inlet face of the SCR catalyst device, flows through the catalyst, and is consumed in the NOx reduction process. Any unconsumed ammonia exiting the SCR system can be reduced to N₂ and other less harmful or less noxious components using an ammonia oxidation catalyst.

[0006] To sufficiently decompose into ammonia, the injected urea must be given adequate time to complete the three stages. The time given to complete the three stages and decompose urea into ammonia before entering the SCR catalyst device is conventionally termed residence time. Some prior art exhaust aftertreatment systems utilize a long tube of a fixed linear decomposition length that extends between the urea injector and SCR catalyst device inlet face. The fixed linear decomposition length of prior art systems must be quite long in order to provide the necessary residence time. Long tubing for urea decomposition often takes up valuable space that could be occupied by other vehicle components and influences the design of the exhaust aftertreatment system. However, shorter decomposition tubes associated with some prior art end-in, end-out and end-in, side-out SCR systems may not provide a sufficiently long residence time to properly evaporate the injected urea.

[0007] Additionally, some prior art exhaust aftertreatment systems, particularly those systems that utilize or require in-line or end-to-end or end-to-side devices, do not provide adequate mixing of the urea/ammonia with the exhaust gas. Inadequate mixing results in a low ammonia vapor uniformity index, which can lead to crystallization/polymerization buildup inside the SCR catalyst device or other SCR system devices, localized aggregation of ammonia, inadequate distribution of the ammonia across the SCR catalyst surface, lower NO conversion efficiency, and other shortcomings.

[0008] Further, many exhaust aftertreatment systems with end-to-end or end-to-side SCR systems fail to adequately distribute exhaust gas across the inlet face of the SCR catalyst device. An uneven distribution of exhaust gas at the SCR catalyst device inlet can result in excessive ammonia slip and less than optimal NOx conversion efficiency. For example, a low exhaust flow distribution index at the SCR catalyst device inlet results in a lower amount of SCR catalyst surface area in contact with the exhaust gases. The lesser the catalyst surface area in contact with the exhaust gases, the lower the NOx reduction efficiency of the SCR catalyst device.

[0009] What is needed in the art is a more efficient mixing of the exhaust gases prior to or at the inlet of the SCR device.

SUMMARY OF THE INVENTION

[0010] The present invention seeks to provide apparatus more completely and uniformly mixing exhaust gas components in an exhaust aftertreatment system.

[0011] In one form, the invention is an inlet for exhaust gases to a selective catalytic reduction (SCR) device hav-

ing a generally cylindrical or oval cross section shape with a central longitudinal axis. The inlet includes an axially directed inlet radially offset from the central longitudinal axis and having an axially directed upstream end and directing exhaust gases in a tangential direction at its downstream end relative to the central longitudinal axis of the SCR component.

[0012] In another form, the invention is an exhaust aftertreatment system including a selective catalytic reduction (SCR) device having a generally cylindrical or oval cross sectional shape and a central longitudinal axis. A plurality of catalysts are housed within the SCR device for exhaust gas flow therethrough. An inlet is radially offset from the central axis and has an axially directed upstream and directing gases in a tangential direction at its downstream end relative to the central axis of the SCR device.

[0013] In an embodiment, the inlet has a curved section adjacent its downstream outlet for imparting a tangential direction to exhaust the exhaust gases.

[0014] In an embodiment, the inlet is, at least, partially formed from a tube in its upstream end.

[0015] In an embodiment, the curved section is a scroll section extending from the circumference of the tube to impart the tangential component and the tube has an end wall.

[0016] In an embodiment, the inlet has a porous bulkhead between the inlet and the interior of the SCR device.

[0017] In an embodiment, the porosity of the bulkhead is provided by a plurality of generally circular openings.

[0018] In an embodiment, the total area of the openings is approximately % of the circumferential cross sectional area of the bulkhead.

[0019] In another embodiment, the inlet is combined with an exhaust aftertreatment system having a housing for the SCR device inlet.

[0020] In an embodiment, each catalyst has a separate flow path from the inlet through the housing for the SCR device.

[0021] In an embodiment, the catalysts are arranged in tandem within the housing for the SCR device.

BRIEF DESCRIPTION OF THE DRAWINGS

[0022] The above-mentioned and other features and advantages of this invention, and the manner of attaining them, will become more apparent and the invention will be better understood by reference to the following description of embodiments of the invention taken in conjunction with the accompanying drawings, wherein:

Fig. 1 is a perspective view of an exhaust aftertreatment system incorporating a mixer according to the present invention; and

Fig. 2 is an expanded fragmentary perspective view of a portion of the exhaust aftertreatment system of Fig. 1 showing a mixer according to the present invention.

[0023] Corresponding reference characters indicate corresponding parts throughout the several views. The exemplifications set out herein illustrate embodiments of the invention, and such exemplifications are not to be construed as limiting the scope of the invention in any manner.

DETAILED DESCRIPTION OF THE INVENTION

[0024] Referring now to the drawings, and more particularly to Fig. 1, there is shown an exhaust aftertreatment system 110 for an agricultural vehicle, such as a combine harvester shown schematically as dashed line 111. The aftertreatment system 110 generally includes exhaust pipe sections 112A, 112B, 112C, a first exhaust aftertreatment device 114 coupled to the exhaust pipe section 112 at a connection point 118, and a second exhaust aftertreatment device 120. Typically, the agricultural vehicle 111 will include additional internal systems for the separation and handling of collected crop material, but these additional systems are omitted from view for brevity of description. It should be appreciated that the aftertreatment system 110 described and illustrated herein does not necessarily need to be included on combine harvesters, but can be incorporated in other industrial vehicles or agricultural vehicles such as windrowers, tractors, etc.

[0025] The exhaust pipe 112A may link the exhaust of an engine, shown schematically as 116, to the first aftertreatment device 114, or the exhaust pipe 112 may link multiple aftertreatment devices 114 together. The exhaust pipe section 112B may have an insulation 122 surrounding it. The insulation 122 may extend along a portion or up to the entire length of the exhaust pipe section 112B. As shown, the insulation 122 spans the length of the exhaust pipe 112B and extends approximately up to the connection point 118. The insulation 122 may be in the form of any known insulation that desirably insulates the exhaust pipe section 112B.

[0026] The aftertreatment device 114 may be coupled to the exhaust pipe 112A in order to reduce nitrous oxides (NOx) and/or diesel particulate matter (DPM). The aftertreatment device 114 may be in the form of an exhaust gas recirculation (EGR) device, a diesel particulate filter (DPF), a selective catalytic reduction (SCR) device, or a catalytic converter such as a diesel oxidation catalyst (DOC).

[0027] The aftertreatment device 114 includes at its outlet section a DEF injection device 124 for injecting diesel exhaust fluid into the exhaust for mixing and reaction with the exhaust stream flowing through exhaust pipe 112B. The resulting gas enters the second exhaust aftertreatment device 120 through the inlet end wall 128 of an outer housing 126 which leads to an outlet end wall 130 connecting with exhaust pipe 112C through connector 118. Exhaust aftertreatment device 120 is an SCR device and it includes a forward SCR catalyst 132 and an aft SCR catalyst 134 oriented in tandem and config-

ured so that parallel exhaust flows pass separately through each of the SCR catalysts 132 and 134. It is important to obtain uniform and complete mixing of DEF with the exhaust gases so that it may allow the systems to properly reduce the oxides of nitrogen. In the event of inadequate mixing or mal-distribution between catalysts 132 and 134, the amount of DEF consumed is increased thereby taking away from the efficiency of the aftertreatment system 110.

[0028] Referring to Figs. 1 and 2, an inlet 136 is provided for the aftertreatment device 120 to provide efficient and effective mixing in accordance with an aspect of the present invention..

[0029] Fig. 2 shows a perspective view of the inlet 136 with adjacent and interacting components in dashed lines. Inlet 136 may include a tubular upstream inlet 138 having a central axis B offset from the central axis A of housing 126. Housing 126 may have a circular or oval cross section configuration. Tube 138 extends to a bulkhead 140 separating the interior of housing 126 into a section 139 adjacent the inlet 136 and a section 141 containing SCR catalyst 132 and 134. Bulkhead 140 is perforated by a series of circular openings 142 providing a multiplicity of flows to the SCR catalysts 132 and 134. The relative porosity of the bulkhead 140 may be selected for particular operating conditions and may be up to approximately 45 % of the surface area of the bulkhead 140. The openings may be circular, as shown, or any other shape proving a plurality of flow paths from section 139 to section 141.

[0030] Tube 138 terminates in an end wall 144, shown as integral with bulkhead 140. A curved scroll section 146 begins at the circumference of tube 138 and extends outward to a point at or adjacent the circumference 143 of the bulkhead 140. The scroll section 146 imparts a tangential direction to a single stream through downstream outlet 148. Although the scroll section 146 is shown as integral with the tube 138, it may be provided as a separate element. The scroll section may be any one of a number of forms that direct exhaust flow to a tangential direction from the upstream end of tube 138.

[0031] In operation, the tangentially directed exhaust flow through inlet 136 creates a vortex inside the housing 126 resulting in strong shear driven mixing of DEF with the exhaust gas. As a result, the DEF is well mixed with the exhaust gas and results less wastage or slippage of the DEF. A benefit resulting from this flow is a uniform distribution and split between the separate exhaust flows directed toward the catalysts 132 and 134. One advantage of the present invention is a more efficient mixing of exhaust gases at the inlet of an SCR device. Another advantage is that the inlet is simplified, compact and has fixed geometry.

[0032] While this invention has been described with respect to at least one embodiment, the present invention can be further modified within the spirit and scope of this disclosure. This application is therefore intended to cover any variations, uses, or adaptations of the invention using

its general principles. Further, this application is intended to cover such departures from the present disclosure as come within known or customary practice in the art to which this invention pertains and which fall within the limits of the appended claims.

Claims

1. An inlet (136) for exhaust gases to a selective catalytic reduction (SCR) device (120) having a generally cylindrical or oval cross section shape with a central longitudinal axis A;
said inlet (136) being characterized by:
- said inlet (136) being radially offset from said central axis A and having an axially directed upstream end (138) and directing exhaust gases in a tangential direction at its downstream outlet (148) relative to the central longitudinal axis A of said SCR device (120).
2. The inlet (136) as claimed in claim 1, further comprising a curved section (146) adjacent its downstream outlet (148) for imparting said tangential direction to exhaust the exhaust gases.
3. The inlet (136) as claimed in claim 2, wherein said inlet (136) is at least partially formed from a tube (138) in its upstream end.
4. The inlet (136) as claimed in claim 3, wherein said curved section is a scroll section (146) extending from the circumference of said tube (138) to impart said tangential component and said tube (138) has an end wall (144).
5. The inlet (136) as claimed in any one of claims 1-5 further comprising a porous bulkhead (140) between said inlet (136) and the interior of the SCR device (120).
6. The inlet (136) as claimed in claim 5, wherein the porosity of the bulkhead (140) is provided by a plurality of generally circular openings (142).
7. The inlet (136) as claimed in claim 6, wherein the total area of the openings (142) is approximately 45 % of the circumferential cross sectional area of the bulkhead (140).
8. An inlet (136) as claimed in any one of the preceding claims further comprising an exhaust aftertreatment system (110) having a housing (126) for said SCR device (120) and a plurality of catalysts (132, 134) housed therein over which the exhaust flows from said inlet (136).
9. The inlet (136) as claimed in claim 8, wherein each catalyst (132, 134) has a separate flow path from

said inlet (136).

10. The inlet (136) as claimed in claim 9, wherein said catalysts (132, 134) are arranged in tandem within said housing (126).

5

10

15

20

25

30

35

40

45

50

55

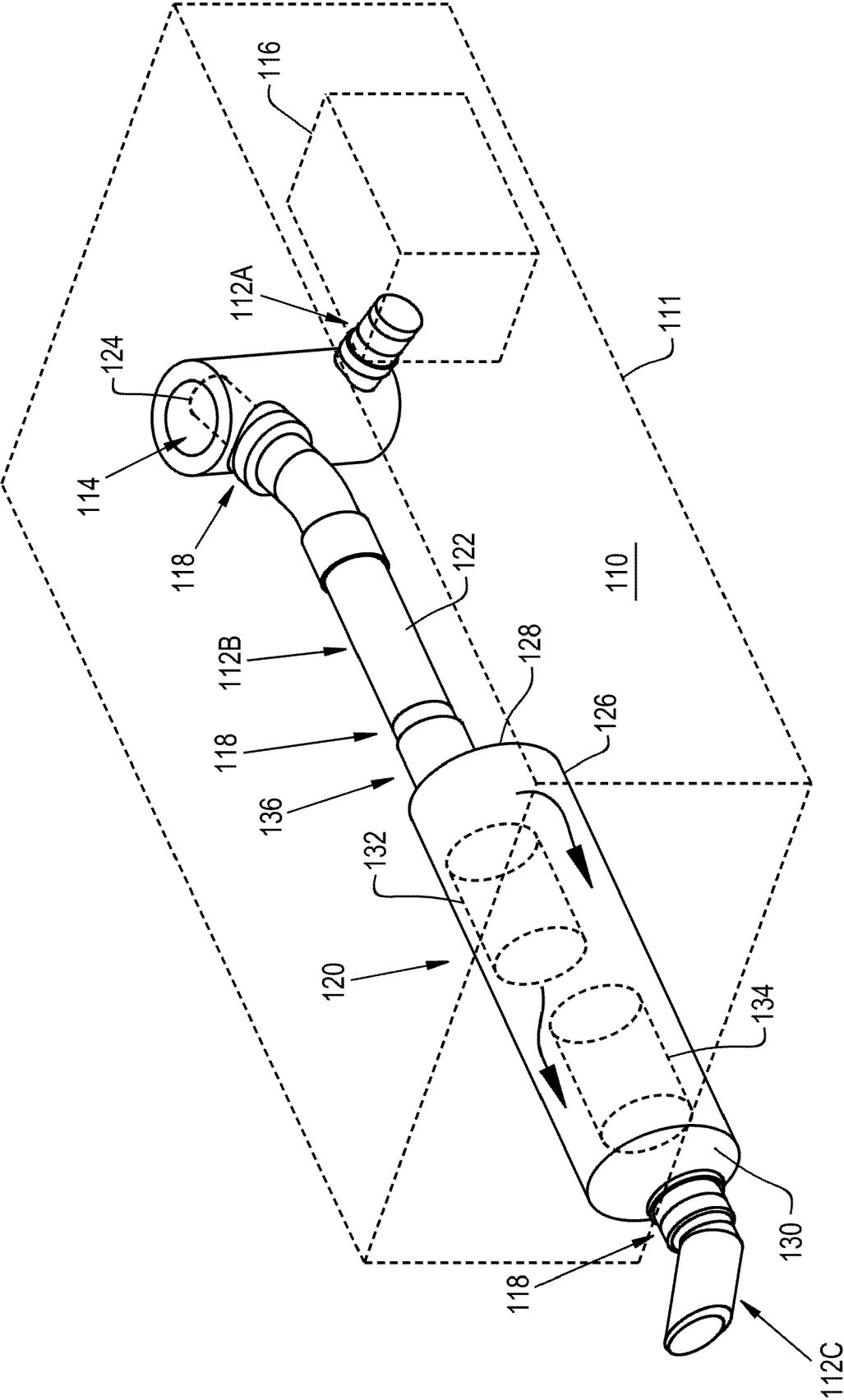


FIG. 1

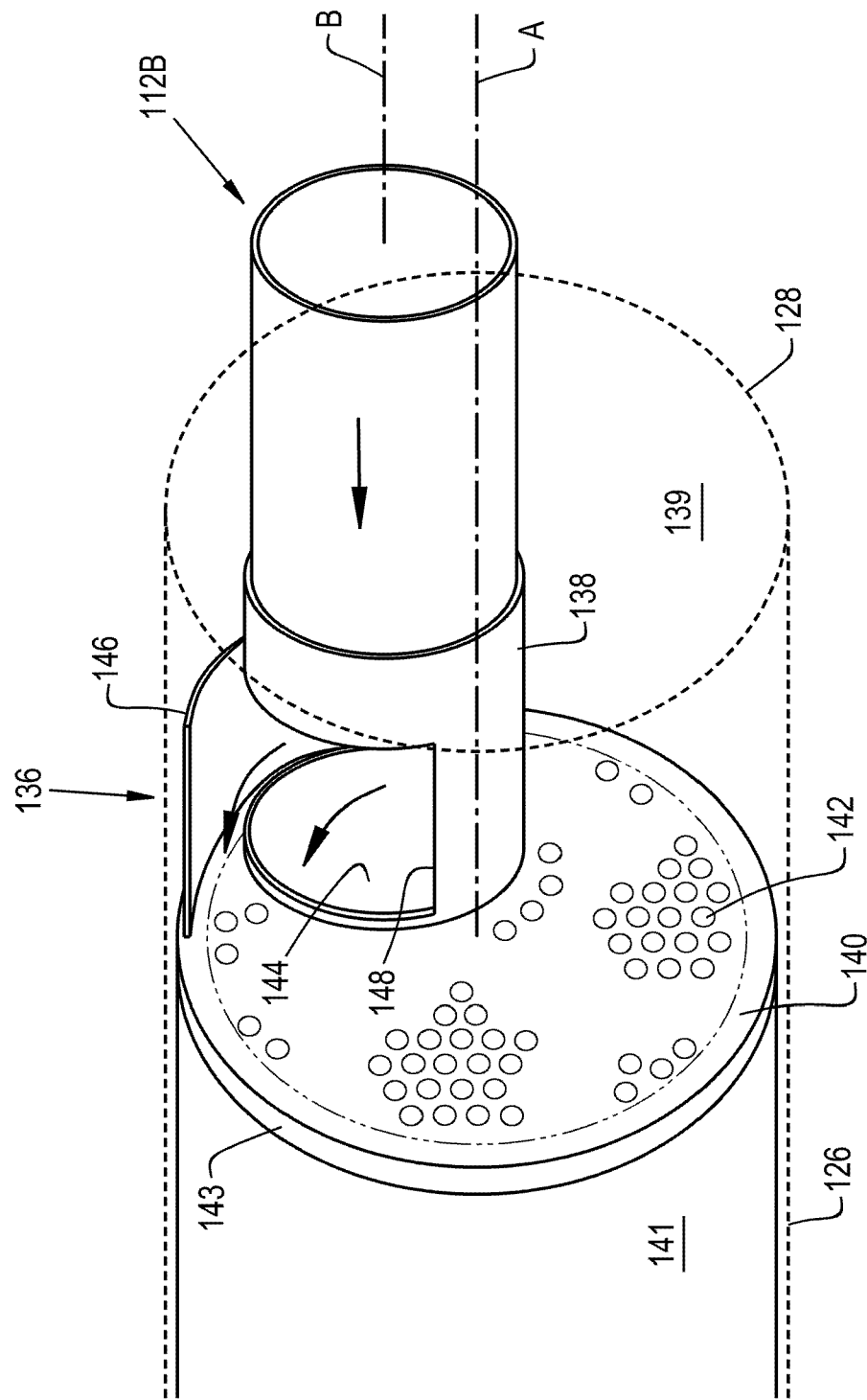


FIG. 2



EUROPEAN SEARCH REPORT

Application Number
EP 18 21 4589

5

10

15

20

25

30

35

40

45

50

55

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	DE 10 2012 008556 A1 (IAV GMBH [DE]) 31 October 2013 (2013-10-31)	1-4,8-10	INV. F01N3/20 F01N13/00 B01F5/00 F01N3/28
Y	* paragraph [0026] * * paragraph [0030]; figures 1-3 *	5-7	
X	US 2014/318112 A1 (SOLBRIG CHARLES E [US] ET AL) 30 October 2014 (2014-10-30) * paragraph [0027] * * paragraph [0031]; figures 1,4-7 *	1-4	
Y	EP 2 607 641 A1 (MTU FRIEDRICHSHAFEN GMBH [DE]; ROTH TECHNIK AUSTRIA [AT]) 26 June 2013 (2013-06-26) * paragraph [0032]; figure 2 *	5-7	
The present search report has been drawn up for all claims			TECHNICAL FIELDS SEARCHED (IPC)
			F01N B01F
Place of search		Date of completion of the search	Examiner
Munich		15 April 2019	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			

EPO FORM 1503 03.02 (P04C01)

**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 18 21 4589

5 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.

15-04-2019

10	Patent document cited in search report	Publication date	Patent family member(s)	Publication date
	DE 102012008556 A1	31-10-2013	NONE	

15	US 2014318112 A1	30-10-2014	NONE	

	EP 2607641 A1	26-06-2013	NONE	

20				
25				
30				
35				
40				
45				
50				
55				

EPO FORM P0459

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