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

(11) EP 2 273 083 A1

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
12.01.2011 Bulletin 2011/02

(51) Int Cl.:
F01N 3/20 *(2006.01)*

(21) Application number: **10168399.3**

(22) Date of filing: **05.07.2010**

(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 SE SI SK SM TR
Designated Extension States:
BA ME RS

(30) Priority: **09.07.2009 US 499850**
09.07.2009 US 499860

(71) Applicant: **Delphi Technologies, Inc.**
Troy, MI 48007 (US)

(72) Inventors:
- **Li, Bob X.**
Grand Blanc, MI 48439 (US)
- **Bonadies, Joseph V.**
Clarkston, MI 48348 (US)

(74) Representative: **Denton, Michael John et al**
Delphi France SAS
Legal Staff
64, avenue de la Plaine de France
BP 65059 Tremblay en France
95972 Roissy CDG Cedex (FR)

(54) Apparatus for maintening a urea solution in a liquid state for treatment of diesel exhaust

(57) A system for keeping a reservoir solution of urea in a liquid state at normally sub-freezing temperatures comprising a reservoir tank module disposed in a solution storage tank (118). Solution in the storage tank is heated partially by passage of heat through the walls of the reservoir tank module. Additional heat is derived from waste heat in engine exhaust gas and is added to the system by passing a portion of the exhaust gas stream through a gas/liquid heat exchanger (152) disposed within the solution in the storage tank (118). The cooled gas is returned to the exhaust system or is sent to the engine intake manifold for EGR.

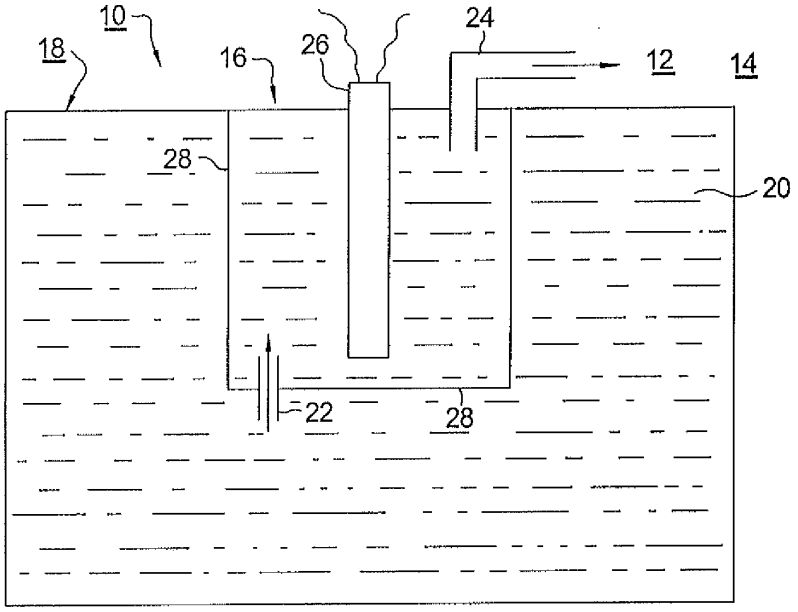

FIG. 1.
(PRIOR ART)

EP 2 273 083 A1

Description

TECHNICAL FIELD

[0001] The present invention relates to emissions control in compression-ignited internal combustion engines; more particularly, to systems for injecting urea into diesel exhaust to scavenge nitrogen oxides and rejuvenating a diesel particulate filter; and most particularly, to a system for heating and liquefying a storage tank solution of urea at normally sub-freezing urea-solution temperatures.

BACKGROUND OF THE INVENTION

[0002] To scavenge oxides of nitrogen (NOx) from the exhaust of compression-ignited (CI) engines, and especially diesel engines, urea injection systems are commonly in use in the prior art. An aqueous urea solution is injected into the hot exhaust pipe, where urea is hydrolyzed into ammonia ahead of a selective catalytic reduction (SCR) converter. Ammonia reacts with NOx trapped on the catalyst face to form N_2, CO_2, and H_2O, thereby lowering the level of noxious emissions in the exhaust.

[0003] A serious problem in the prior art is that at temperatures below about -11°C, the urea solution can freeze. Thus, a thermal heating system and method are required to thaw the solid solution into a liquid solution (or to keep the solution from freezing) to permit a pump to draw solution for delivery into an engine emissions abatement system.

[0004] A typical prior art urea supply system comprises a relatively small reservoir tank module from which liquid urea solution is dispensed into a diesel engine exhaust system, and a larger storage tank in which the tank module is immersed. The tank module contains a resistance heater that can liquefy suitable quantities of solution in a short time upon engine startup under cold conditions, as is required to meet government air pollution standards. Solution in the surrounding storage tank then is heated by transfer of heat through the walls of the heated reservoir tank module.

[0005] It is an important operating requirement that the storage tank be able to re-supply the reservoir tank module within a short time after starting of the engine. In prior art systems when the solution in the storage tank is frozen, meeting this requirement can be difficult because of limited heat flow through the walls of the reservoir tank module, which typically is formed of a plastic polymer having relatively low thermal conductivity.

[0006] US Patent No. 6,387,336 discloses generally that an electric heating system and/or a heating device that uses waste heat of the engine coolant and/or the exhaust gas can be used to heat the frozen urea.

[0007] Published US Patent Application No. US 2008/0092531 discloses use of hot engine coolant to heat the frozen urea in both the storage tank and the supply line from the reservoir tank module to the point of injection of urea into the exhaust system. The specification describes a separate coolant conduit embedded in the urea tank for heating the tank, and a double pipe construction surrounding the urea feed pipe for heating the urea flowing through the feed pipe. The inside of the double pipe arrangement provides a flow path for the urea while a jacketingsurrounding outer pipe carries the heated coolant, which may flow counter to the direction of flow of the urea. Also disclosed is the use of heat from a proximate exhaust pipe, which heat may be used to heat a non-jacketed urea feed pipe from a storage tank to the emissions abatement system. Alternatively, exhaust gas may be passed through the jacket of a doublewalled feed pipe between the storage tank and the point of injection. It is not disclosed or suggested to pass exhaust gas through a heat exchanger disposed within the stored solution in the storage tank.

[0008] What is needed in the art is an improved storage system for urea solution wherein frozen urea solution in a urea storage tank may be liquefied at a rate sufficient to maintain replenishment of the reservoir tank module.

[0009] It is a principal object of the present invention to provide a reliable flow of liquid urea solution at ambient temperatures below the freezing point of the solution.

SUMMARY OF THE INVENTION

[0010] Briefly described, a system for keeping a reservoir solution of urea in a liquid state at normally sub-freezing temperatures comprises a reservoir tank module disposed in a storage tank. The reservoir tank module preferably includes a level sensing apparatus, inlet and outlet ports for supplying and withdrawing urea solution, and at least one heating element. The walls of the reservoir tank module are preferably immersed in urea solution contained in the storage tank, which solution is partially heated by passage of heat through the walls of the reservoir tank module.

[0011] In accordance with the present invention, additional heat for melting frozen urea solution in the storage tank is derived from waste heat in engine exhaust gas and is added to the system by passing a portion of the exhaust gas stream through a gas/liquid heat exchanger disposed within the solution in the storage tank. After being passed through the heat exchanger, the cooled exhaust gas may be conveniently disposed of either by being returned to the tailpipe or by feeding the exhaust gas into the engine intake manifold in a method of exhaust gas recirculation (EGR).

BRIEF DESCRIPTION OF THE DRAWINGS

[0012] The present invention will now be described, by way of example, with reference to the accompanying drawings, in which:

FIG. 1 is an elevational schematic view of a prior art system for keeping a reservoir solution of urea in a

liquid state at normally sub-freezing temperatures;

FIG. 2 is a schematic drawing of a first embodiment in accordance with the present invention of a system for keeping a reservoir solution of urea in a liquid state at normally sub-freezing temperatures, showing passage of a portion of the engine exhaust gas stream through a gas/liquid heat exchanger disposed in the urea solution storage tank; and

FIG. 3 is a schematic drawing of a second embodiment in accordance with the present invention of a system for keeping a reservoir solution of urea in a liquid state at normally sub-freezing temperatures, showing passage of a portion of the engine exhaust gas stream through a gas/liquid heat exchanger disposed in the urea solution storage tank as in FIG. 2 and thence to the engine intake manifold for EGR use.

[0013] The exemplifications set out herein illustrate currently-preferred embodiments of the present invention, and such exemplifications are not to be construed as limiting the scope of the invention in any manner.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0014] Referring to FIG. 1, a portion of an exemplary prior art system 10 for supplying a solution 20 of urea to a diesel exhaust emissions abatement system 12 for a diesel engine 14 comprises a reservoir tank module 16 disposed within a storage tank 18 for urea solution 20. Solution 20 enters tank module 16 via an inlet 22 and is dispensed via an outlet 24. A heater 26 is disposed within tank module 16 for liquefying solution 20 within module 16. Excess heat from heater 26 is intended to pass through the walls 28 of tank module 16 and locally liquefy solution 20 in proximity to tank module 16 and inlet 22 to allow gravitational replenishment of solution into tank module 16. As described above, a problem exists in operation of prior art systems 10 in that walls 28 of reservoir tank module 16 are typically formed of a plastic polymer having relatively low thermal conductivity such that at extreme low temperature conditions insufficient heat is passed into storage tank 18 to maintain an adequate rate of liquefaction and replenishment.

[0015] In a first method for replenishing the reservoir tank module in accordance with the present invention, (and referring now to FIG. 2 and a first embodiment 110 of an improved system for supplying a solution of urea to a diesel exhaust emissions control system) a portion 130 of the exhaust stream 132 from engine 14 is diverted, preferably following the diesel particulate filter 134 and before the engine muffler 136 and tail pipe 138. Portion 130 is preferably diverted by a porting mechanization 140 attached to the vehicle exhaust pipe, such as an electrically-operated valve assembly. A pressure sensor 146 combined with a temperature sensor 148 on the bypass flow line 150 may be employed to enable calculation of the flow rate of exhaust portion 130 and thereby assist in controlling flow through porting mechanism 140. The diverted exhaust gas portion 130 is directed through a gas/liquid heat exchanger 152 disposed within the urea solution 20 in urea storage tank 118. This arrangement can create an exhaust-disposal problem if, for example, system 110 is conveniently located within the engine compartment of a vehicle. Therefore, cooled exhaust gas 130' exits storage tank 118 via a tank port 154 and is directed back into the engine exhaust system via return line 156. The exit and return points in the exhaust system for gas 130,130' can be selected anywhere that provides a pressure drop sufficient to cause gas flow through heat exchanger 152, but preferably either upstream or downstream of all emissions abatement components such that no untreated exhaust escapes the exhaust system.

[0016] Preferably, bypass flow line 150 for exhaust gas portion 130 passes through reservoir tank module 116 where some auxiliary heating of solution 20 occurs by heat loss from line 150.

[0017] Referring now to FIG. 3, a second embodiment 210 of an improved system for supplying a solution of urea to a diesel exhaust emissions control system is very similar to first embodiment 110 and employs numerous identical components, so indicated by the same numbers as in FIG. 2. The difference is that, instead of piping cooled exhaust gas 130' back into the exhaust system via return line 156, gas 130' is piped via line 256 to the intake manifold of engine 14 for use in an EGR method as is well known in the engine arts. Otherwise, the flow path of gas 130 is substantially the same as in FIG. 2.

[0018] While the invention has been described by reference to specific embodiments, it should be understood that numerous changes may be made within the spirit and scope of the inventive concepts described. Accordingly, it is intended that the invention not be limited to the described embodiments, but will have full scope defined by the language of the following claims.

Claims

1. A system for keeping a solution of urea in a liquid state at normally sub-freezing temperatures or liquefying such solution if frozen, for delivery to an emissions abatement system of an internal combustion engine, comprising:

   a) a storage tank for said urea solution;

   b) first apparatus for deriving an exhaust gas portion from an exhaust system of said engine; and

   c) second apparatus for exchanging heat from said exhaust gas portion with said solution of urea in said storage tank.

2. A system in accordance with Claim 1 wherein said second apparatus includes said storage tank and a gas/liquid heat exchanger disposed within said stor-

age tank.

3. A system in accordance with Claim 1 wherein said second apparatus includes at least one of a temperature sensor and a pressure sensor.

4. A system in accordance with Claim 1 wherein said first apparatus includes a diverter valve mounted on said exhaust system for diverting said exhaust gas portion from an exhaust gas stream flowing therewithin.

5. An internal combustion engine comprising a system for keeping a reservoir solution of urea in a liquid state at normally sub-freezing temperatures, or liquefying such solution if frozen, for delivery to an emissions abatement system of an internal combustion engine, wherein said system includes,
a storage tank for said urea solution,
first apparatus for deriving an exhaust gas portion from an exhaust system of said engine, and
second apparatus for exchanging heat from said exhaust gas portion with said solution of urea in said storage tank.

6. A method for keeping a reservoir solution of urea in a liquid state at normally sub-freezing temperatures, or liquefying such solution if frozen, for delivery to an emissions abatement system of an internal combustion engine, comprising the steps of:

a) providing a storage tank for said urea solution;
b) providing a gas/liquid heat exchanger within said urea solution in said storage tank;
c) deriving an exhaust gas portion from an exhaust system of said engine; and
d) passing said exhaust gas portion through said gas/liquid heat exchanger to heat said solution of urea.

7. A method in accordance with Claim 6 further comprising the step of returning said exhaust gas portion from said gas/liquid heat exchanger to said exhaust system.

8. A method in accordance with Claim 6 further comprising the step of directing said exhaust gas portion from said gas/liquid heat exchanger to an intake manifold of said engine.

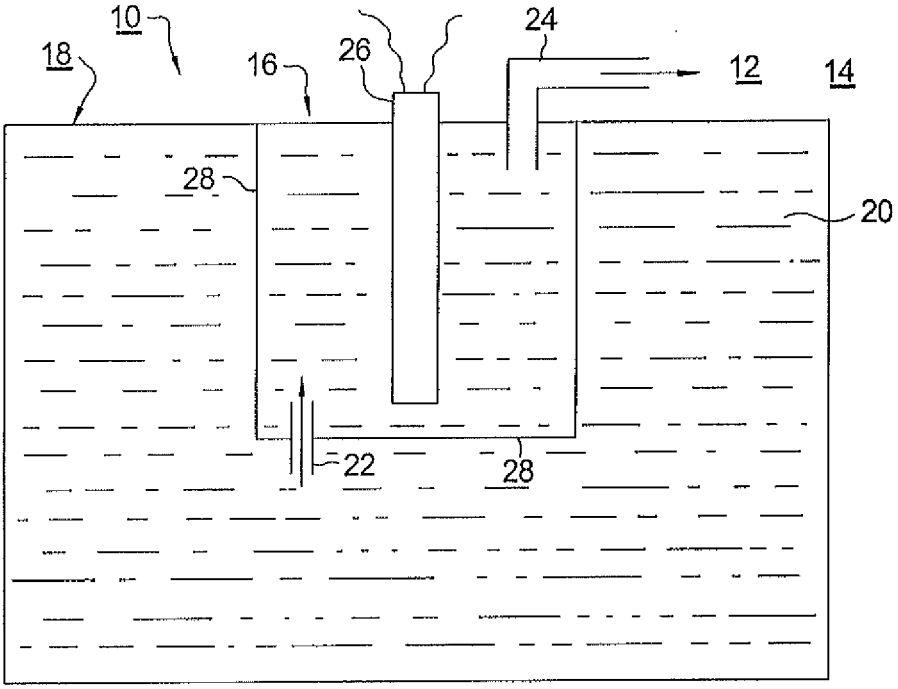

FIG. 1.
(PRIOR ART)

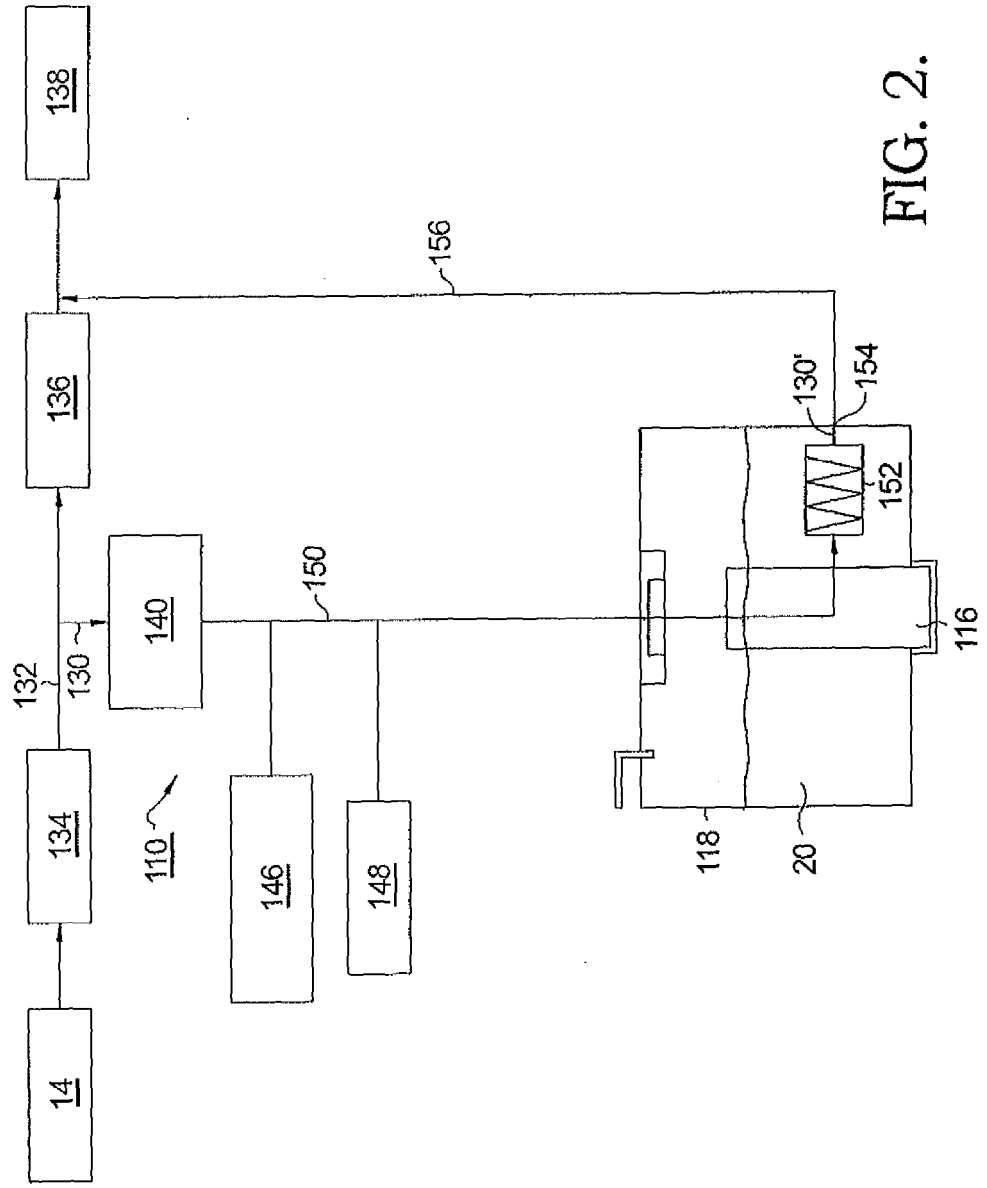
138
136
134
14
132
130
140
110
146
148
150
156
130'
154
152
116
118
20

FIG. 2.

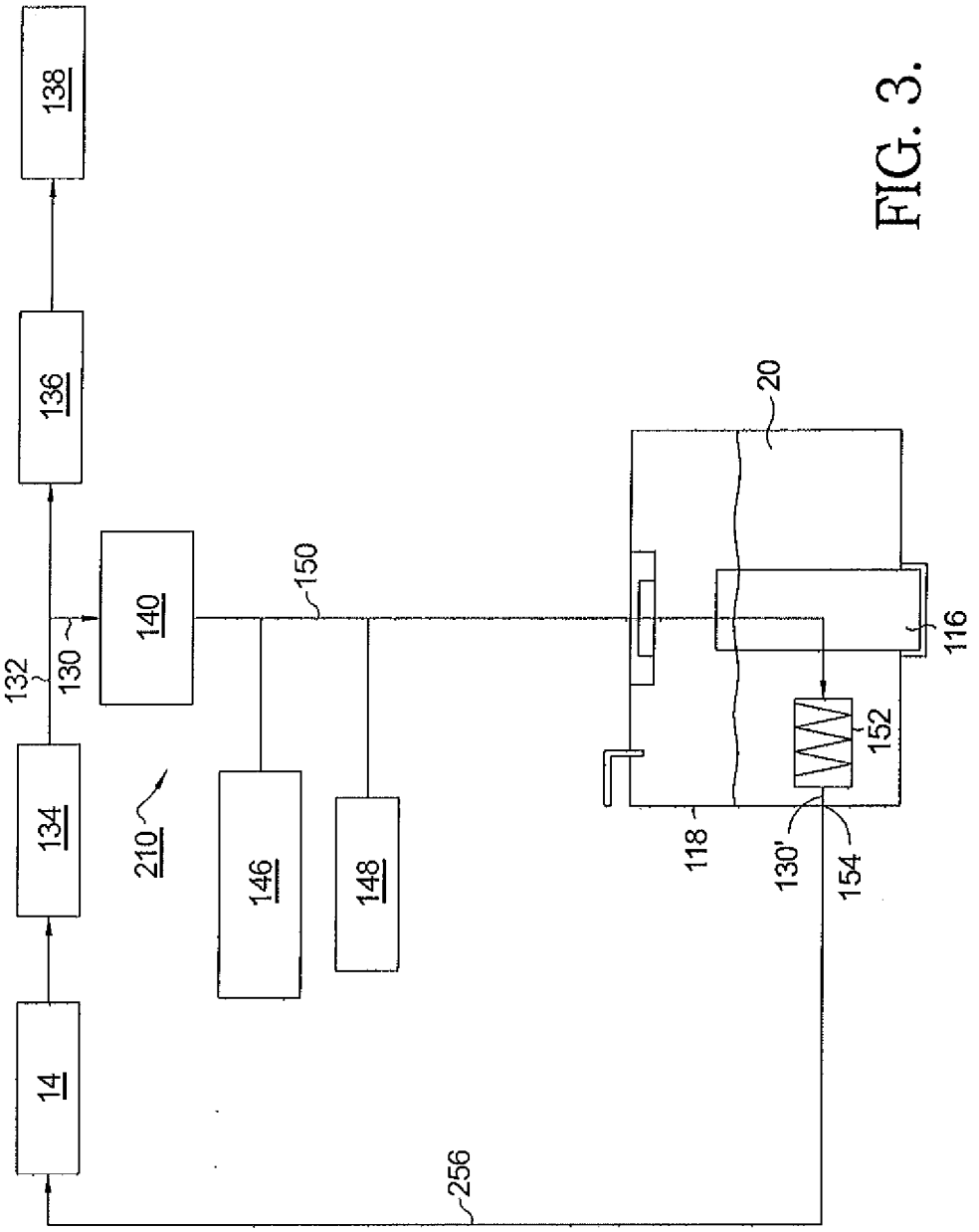
138
136
134
14
132
130
140
150
210
146
148
20
116
152
118
130'
154
256

FIG. 3.

Europäisches Patentamt
European Patent Office
Office européen des brevets

EUROPEAN SEARCH REPORT

Application Number
EP 10 16 8399

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	WO 01/38704 A1 (CATERPILLAR INC [US]) 31 May 2001 (2001-05-31) * page 5, line 22 - page 6, line 2; figure 1 *	1-8	INV. F01N3/20
X,P	DE 10 2008 001020 A1 (BOSCH GMBH ROBERT [DE]) 8 October 2009 (2009-10-08) * paragraph [0028]; figure 3 *	1-8	
A	EP 2 065 578 A1 (INT ENGINE INTELLECTUAL PROP [US]) 3 June 2009 (2009-06-03) * column 4, line 24 - column 5, line 2; figure 1 *	1,5,6	

TECHNICAL FIELDS SEARCHED (IPC)
F01N

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	7 October 2010	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 03.82 (P04C01)

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 10 16 8399

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.

07-10-2010

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 0138704 A1	31-05-2001	AU 8017000 A	04-06-2001
		DE 10085228 T0	31-10-2002
		US 6363771 B1	02-04-2002
DE 102008001020 A1	08-10-2009	NONE	
EP 2065578 A1	03-06-2009	CA 2644722 A1	28-05-2009
		JP 2009168013 A	30-07-2009
		KR 20090055510 A	02-06-2009

EPO FORM P0459

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

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- US 6387336 B **[0006]**
- US 20080092531 A **[0007]**