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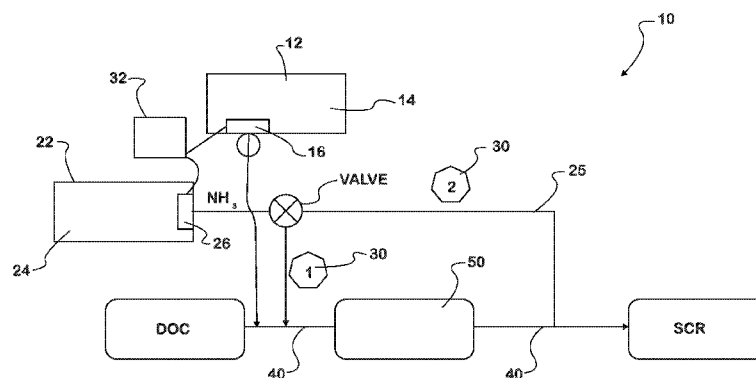
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(54) **Title:** SUPPLEMENTAL AMMONIA STORAGE AND DELIVERY SYSTEM

**FIG. 1**

(57) **Abstract:** An exhaust after-treatment system is described. Generally speaking, the system includes separate primary and secondary NO_x reducing systems for delivering reductant (e.g. urea and ammonia) to an exhaust stream, a sensor system for determining relevant operating conditions and an electronic control module for activating the reducing systems. The two NO_x reducing systems include flow control modules coupled to the electronic control module. Methods for reducing NO_x in an exhaust stream are also described. Generally speaking, the methods include the steps of determining a need for NO_x reduction in an exhaust stream, determining temperature of exhaust stream, and injecting at least one of a primary reductant and a secondary reductant into the exhaust stream based on the determined temperature of the exhaust stream. Typically, the primary reductant comprises urea and the secondary reductant comprises ammonia.

SUPPLEMENTAL AMMONIA STORAGE AND DELIVERY SYSTEM

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the benefit of United States Patent Application Serial No. 61/495,485 filed on June 10, 2011.

TECHNICAL FIELD

[0002] The present disclosure relates to a system and method for treating an exhaust stream in a vehicle exhaust system. Particularly, the present disclosure provides a method for improving the reduction of nitrogen oxides (NO_x) in the exhaust gas stream through delivery of a suitable amount of reductant into a vehicle exhaust stream.

BACKGROUND

[0003] Diesel engines are efficient, durable and economical. Diesel exhaust, however, can harm both the environment and people. To reduce this harm, governments, such as the United States and the European Union, have proposed stricter diesel exhaust emission regulations. These environmental regulations require diesel engines to meet the same pollution emission standards as gasoline engines. Typically, to meet such regulations and standards, diesel engine systems require equipment additions and modifications.

[0004] For example, a lean burning engine provides improved fuel efficiency by operating with an amount of oxygen in excess of the amount necessary for complete combustion of the fuel. Such engines are said to run "lean" or on a "lean mixture." However, the increase in fuel efficiency is offset by the creation of undesirable pollution emissions in the form of nitrogen oxides (NO_x). Nitrogen oxide emissions are regulated through regular emission testing requirements. One method used to reduce NO_x emissions from lean burn internal combustion engines is known as selective catalytic reduction (SCR). When used to reduce NO_x emissions from a diesel engine, selective catalytic reduction involves injecting atomized urea into the exhaust stream of the engine.

[0005] The main components of an SCR system are a tank for storing Diesel Exhaust Fluid (DEF) and an injection system for delivering the DEF into the exhaust, as well as an SCR catalytic chamber for the NO_x reduction to occur. An onboard diagnostic system monitors the

DEF level and indicates when the storage tank needs to be refilled. However, while the DEF is a non-hazardous, high-purity, colorless solution containing 32.5% urea, its high water content (over 65% deionized water) makes DEF very susceptible to freezing in the DEF tank at cold ambient temperatures and difficult to vaporize in cool exhaust streams.

[0006] Because the fluid cannot be sprayed if it is frozen in the DEF tank and poor vaporization in cool exhaust streams leads to deposit formation, DEF is unusable in these conditions. Accordingly, in order to be in compliance with emission standards, alternate dosing is needed during such times. The present system and methods solve these and other problems associated with prior art NO_x reduction systems.

SUMMARY

[0007] An exhaust after-treatment system is described and claimed. Generally speaking, the system comprises separate primary and secondary NO_x reducing systems for delivering reductant (e.g. urea and ammonia) to an exhaust stream, a sensor system for determining relevant operating conditions and an electronic control module for activating the reducing systems. The two NO_x reducing systems include flow control modules coupled to the electronic control module.

[0008] In an embodiment of the system, the sensor system sends inputs to the electronic control module representative of relevant operating conditions, such as flow rate, temperature, and the like. The electronic control module receives the sensor inputs and activates at least one of either the primary or the secondary flow control module based on those sensor inputs.

[0009] In an embodiment of the system, the secondary NO_x reducing system comprises a refillable canister having a supply of ammonia, a heating element coupled to the refillable canister, tubing for fluidly connecting the refillable canister with vehicle exhaust and an injection system connected to the tubing for injecting ammonia into the vehicle exhaust.

[0010] Additionally, the supplemental NO_x reduction device for use in a vehicle exhaust after-treatment system is also described and claimed. Generally speaking, the device comprises a refillable canister having a supply of ammonia, a heating element coupled to the refillable canister, a flow control module connected to the refillable canister for regulating the discharge of ammonia from the refillable canister, tubing for fluidly connecting the refillable canister with a vehicle exhaust, an injection system connected to the tubing for injecting ammonia into the vehicle exhaust, a sensor system for determining relevant operating conditions and sending

inputs representative of the conditions, and an electronic control module for receiving sensor inputs and activating the flow control module based on sensor inputs.

[0011] In an embodiment of the supplemental NO_x reduction device, the sensor system comprises at least one of an exhaust gas temperature sensor, an ambient temperature sensor, an exhaust gas NO_x sensor, and a primary NO_x reductant flow sensor. In one embodiment, the device is coupled to a vehicle exhaust line upstream of a primary reductant source and upstream of a SCR and/or a NPF (NO_x particulate filter which is a DPF with SCR coating and no PGM).

[0012] Methods for reducing NO_x in an exhaust stream are also described and claimed. Generally speaking, the methods comprise the steps of determining a need for NO_x reduction in an exhaust stream, determining temperature of exhaust stream, and injecting at least one of a primary reductant and a secondary reductant into the exhaust stream based on the determined temperature of the exhaust stream. Typically, the primary reductant comprises urea and the secondary reductant comprises ammonia.

[0013] In an embodiment, the method comprises the further steps of injecting the primary reductant into the exhaust stream, determining the NO_x level in the exhaust stream after injection of the primary reductant, and injecting the secondary reductant into the exhaust stream if the NO_x level is below a threshold level. In one embodiment, the primary reductant is injected into the exhaust stream when the determined temperature of the exhaust stream is in the range of from about 200° C to about 500° C. The secondary reductant can be dosed when any or all of the following conditions are satisfied: the exhaust temperature is outside of the range of about 200° C - 500° C, the ambient temperature is less than -11°C, or if the DEF tank is frozen (determined by actual sensing, calibrated values from a map or an algorithm).

BRIEF DESCRIPTION OF THE DRAWINGS

[0014] FIG. 1 is a schematic illustrating one embodiment of the present system;

[0015] FIG. 2 is a schematic illustrating an alternate embodiment of the present system; and,

[0016] FIG. 3 is a schematic illustrating yet another alternate embodiment of the present system.

DETAILED DESCRIPTION

[0017] Referring to FIGS. 1-3, an exhaust after-treatment system 10 is illustrated. The system 10 comprises a primary NO_x reducing system 12 which is used for delivering a reductant, such as liquid urea (aka, diesel exhaust fluid), to an exhaust stream 40. The primary system 12 includes a refillable tank 14 and a primary flow control module 16 which regulates the flow of reductant from the tank 14 into the exhaust stream 40. A secondary NO_x reducing system 22 is also a component of the after-treatment system 10, and also delivers a reductant, in one embodiment ammonia, to the exhaust stream 40. The secondary system 22 includes a refillable tank 24 for storing the reductant, and a flow control module 26, coupled to the tank 24, which regulates the flow of reductant from the secondary system 20 into the exhaust stream 40.

[0018] A sensor system 30 is used for determining relevant operating conditions of the vehicle (not shown), particularly of the exhaust stream, and for sending electronic inputs representative of these conditions to an electronic control module 32. The electronic control module 32 receives the sensor system inputs and activates at least one of either the primary flow control module 16 or the secondary flow control module 26 based on the sensor inputs. Of course, conditions may exist where the electronic control module 32 receives inputs which result in neither of the modules being activated.

[0019] As illustrated, the primary system 12 will dose DEF from the primary system 12 into the exhaust stream 40 upstream of the NPF 50. The sensor system 30 comprises at least one of a selection of sensors including an exhaust gas temperature sensor, an ambient temperature sensor, an exhaust gas NO_x sensor, and a primary NO_x reductant flow sensor. The selected sensor(s) is/are coupled to the appropriate system component and to the electronic control module 32 to deliver information which then is used to determine which of the flow modules, if either, to activate.

[0020] For example, the DEF will only be dosed into the exhaust from the primary system 12 when the exhaust temperature is within the range of from about 200° C to about 500° C. That requirement excludes vehicle cold starts, in which case, the secondary system 22 will be used to dose ammonia into the exhaust stream 40 for NO_x reduction.

[0021] As shown, the secondary system 22 may inject ammonia upstream of the NPF 50 or downstream of the NPF 50. The latter scenario being used when the temperature of the NPF 50 is too high for desired conversion efficiency—e.g., during periods of active regeneration of the

DPF. The secondary system 22 will also dose upstream of the NPF 50 when an ambient temperature sensor indicates a sub-threshold temperature (e.g., -11°C) resulting in a frozen DEF tank 14. Also, as mentioned, the secondary system 22 will dose ammonia into the exhaust stream 40 downstream of the NPF 50 during active regeneration of a diesel particulate filter (DPF).

[0022] Another situation which may call for dosing from the secondary system 22 is when the NO_x level is so high the primary system 12 is unable to sufficiently reduce the NO_x to an acceptable level. The secondary system 22 may then be activated by the electronic control module 32, via the flow module 26, to assist the primary system 12.

[0023] The secondary NO_x reducing system 22 comprises a refillable canister 24 having a supply of ammonia, a heating element (not shown) coupled to the refillable canister 24, tubing 25 for fluidly connecting the refillable canister 24 with the exhaust stream 40, and an injection system (not shown) connected to the tubing 25 for injecting ammonia into the vehicle exhaust. These components are well-understood by those skilled in the art.

[0024] In the alternate embodiments of FIGS. 2 and 3, the primary system 12 and the secondary system 22 both dose into the exhaust stream 40 downstream of the DPF 52. All other components and operations are similar to that of the embodiment of FIG. 1.

[0025] According to the disclosed systems, a method for reducing NO_x in an exhaust stream can be generally understood. The method begins with the step of determining a need for NO_x reduction in an exhaust stream. This can be done in a variety of ways using sensors to determine or approximate the NO_x level of the exhaust stream. The method continues with determining the temperature of exhaust stream, which can be done simultaneously to determining or estimating the NO_x level. Again, temperature sensors properly positioned provide a suitable means for determining the exhaust temperature. As previously stated, the sensor readings from these steps will determine the operation of the NO_x reduction system 10. Based on the sensor system inputs, at least one of a primary reductant and a secondary reductant is dosed by injection into the exhaust stream.

[0026] In a particular embodiment, the primary reductant is injected into the exhaust stream, and a determination is made that the primary reductant is insufficient to reduce the NO_x concentration to an acceptable level. Accordingly, the secondary reductant is then dosed into the exhaust stream, by injection, until the NO_x level falls below a threshold level.

[0027] Where the sensor system indicates the temperature of the exhaust stream is below about 200° C, the primary reductant is initially injected into the exhaust stream. The secondary reductant is injected into the exhaust stream if the exhaust gas temperature is below this value, the DEF tank is frozen, the NPF is regenerating (dosing only to separated SCR brick), or if additional reductant is required in the SCR brick.

CLAIMS

What is claimed is:

1. An exhaust after-treatment system comprising:

a primary NO_x reducing system for delivering a reductant to an exhaust stream, the primary system having a primary flow control module;

a secondary NO_x reducing system for delivering a reductant to an exhaust stream, the secondary system having a secondary flow control module;

a sensor system for determining relevant operating conditions and sending inputs representative of the conditions; and

an electronic control module for receiving sensor inputs and activating one of either the primary or the secondary flow control module based on sensor inputs.

2. The exhaust after-treatment system of Claim 1, wherein the secondary NO_x reducing system comprises:

a refillable canister having a supply of ammonia;

a heating element coupled to the refillable canister;

tubing for fluidly connecting the refillable canister with a vehicle exhaust; and

an injection system connected to the tubing for injecting ammonia into the vehicle exhaust.

3. The exhaust after-treatment system of Claim 1, wherein the reductant in the primary NO_x reducing system is different than the reductant in the secondary NO_x reducing system.

4. The exhaust after-treatment system of Claim 3, wherein the reductant in the primary NO_x reducing system comprises urea.

5. The exhaust after-treatment system of Claim 3, wherein the reductant in the secondary NO_x reducing system comprises ammonia.

6. A supplemental NO_x reduction device for use in an exhaust after-treatment system, the device comprising:

a refillable canister having a supply of ammonia;

a heating element coupled to the refillable canister;

a flow control module connected to the refillable canister for regulating the discharge of ammonia from the refillable canister;

tubing for fluidly connecting the refillable canister with a vehicle exhaust;

an injection system connected to the tubing for injecting ammonia into the vehicle exhaust;

a sensor system for determining relevant operating conditions and sending inputs representative of the conditions; and

an electronic control module for receiving sensor inputs and activating the flow control module based on sensor inputs.

7. The supplemental NO_x reduction device of Claim 6, wherein the sensor system comprises at least one of an exhaust gas temperature sensor, an ambient temperature sensor, an exhaust gas NO_x sensor, and a primary NO_x reductant flow sensor.

8. The supplemental NO_x reduction device of Claim 6, wherein the device is coupled to a vehicle exhaust line upstream of a primary reductant source.

9. The supplemental NO_x reduction device of Claim 6, wherein the device is coupled to a vehicle exhaust line upstream of a DPF.

10. The supplemental NO_x reduction device of Claim 6, wherein the device is coupled to a vehicle exhaust line upstream of a NPF.

11. A method for reducing NO_x in an exhaust stream, the method comprising the steps of:

determining a need for NO_x reduction in an exhaust stream;

determining temperature of exhaust stream; and

injecting at least one of a primary reductant and a secondary reductant into the exhaust stream based on the determined temperature of the exhaust stream.

12. The method of Claim 11, wherein the primary reductant comprises urea and the secondary reductant comprises ammonia.

13. The method of Claim 11, further comprising the steps of:

injecting the primary reductant into the exhaust stream;

determining the NO_x level in the exhaust stream after injection of the primary reductant;
and

injecting the secondary reductant into the exhaust stream if the NO_x level is above a threshold level.

14. The method of Claim 11, wherein the primary reductant is injected into the exhaust stream when the determined temperature of the exhaust stream is in the range of from about 200° C to about 500° C.

15. The method of Claim 13, wherein the secondary reductant is injected into the exhaust stream when the determined temperature of the exhaust stream is either below about 200° C or above about 500° C.

AMENDED CLAIMS

received by the International Bureau on 11 July 2012 (11.07.12)

What is claimed is:

1. An exhaust after-treatment system comprising:
 - a primary NO_x reducing system for delivering a reductant to an exhaust stream, the primary system having a primary flow control module;
 - a secondary NO_x reducing system for delivering a reductant to an exhaust stream, the secondary system having a secondary flow control module;
 - a sensor system for determining relevant operating conditions and sending inputs representative of the conditions; and
 - an electronic control module for receiving sensor inputs and activating one of either the primary or the secondary flow control module based on sensor inputs.
2. The exhaust after-treatment system of Claim 1, wherein the secondary NO_x reducing system comprises:
 - a refillable canister having a supply of ammonia;
 - a heating element coupled to the refillable canister;
 - tubing for fluidly connecting the refillable canister with a vehicle exhaust; and
 - an injection system connected to the tubing for injecting ammonia into the vehicle exhaust.
3. The exhaust after-treatment system of Claim 1, wherein the reductant in the primary NO_x reducing system is different than the reductant in the secondary NO_x reducing system.
4. The exhaust after-treatment system of Claim 3, wherein the reductant in the primary NO_x reducing system comprises urea.
5. The exhaust after-treatment system of Claim 3, wherein the reductant in the secondary NO_x reducing system comprises ammonia.

6. A supplemental NO_x reduction device for use in an exhaust after-treatment system, the device comprising:

- a refillable canister having a supply of ammonia;
- a heating element coupled to the refillable canister;
- a flow control module connected to the refillable canister for regulating the discharge of ammonia from the refillable canister;
- tubing for fluidly connecting the refillable canister with a vehicle exhaust;
- an injection system connected to the tubing for injecting ammonia into the vehicle exhaust;
- a sensor system for determining relevant operating conditions and sending inputs representative of the conditions; and
- an electronic control module for receiving sensor inputs and activating the flow control module based on sensor inputs.

7. The supplemental NO_x reduction device of Claim 6, wherein the sensor system comprises at least one of an exhaust gas temperature sensor, an ambient temperature sensor, an exhaust gas NO_x sensor, and a primary NO_x reductant flow sensor.

8. The supplemental NO_x reduction device of Claim 6, wherein the device is coupled to a vehicle exhaust line upstream of a primary reductant source.

9. The supplemental NO_x reduction device of Claim 6, wherein the device is coupled to a vehicle exhaust line upstream of a DPF.

10. The supplemental NO_x reduction device of Claim 6, wherein the device is coupled to a vehicle exhaust line upstream of a NPF.

11. A method for reducing NO_x in an exhaust stream, the method comprising the steps of:
determining a need for NO_x reduction in an exhaust stream;

determining temperature of exhaust stream;

injecting at least one of a primary reductant and a secondary reductant into the exhaust stream based on the determined temperature of the exhaust stream, wherein the primary reductant comprises urea and the secondary reductant comprises ammonia;

injecting the primary reductant into the exhaust stream;

determining the NO_x level in the exhaust stream after injection of the primary reductant;

and

injecting the secondary reductant into the exhaust stream if the NO_x level is above a threshold level, wherein the primary reductant is injected into the exhaust stream when the determined temperature of the exhaust stream is in the range of from about 200° C to about 500° C.

12. The method of Claim 11, wherein the secondary reductant is injected into the exhaust stream when the determined temperature of the exhaust stream is either below about 200° C or above about 500° C.

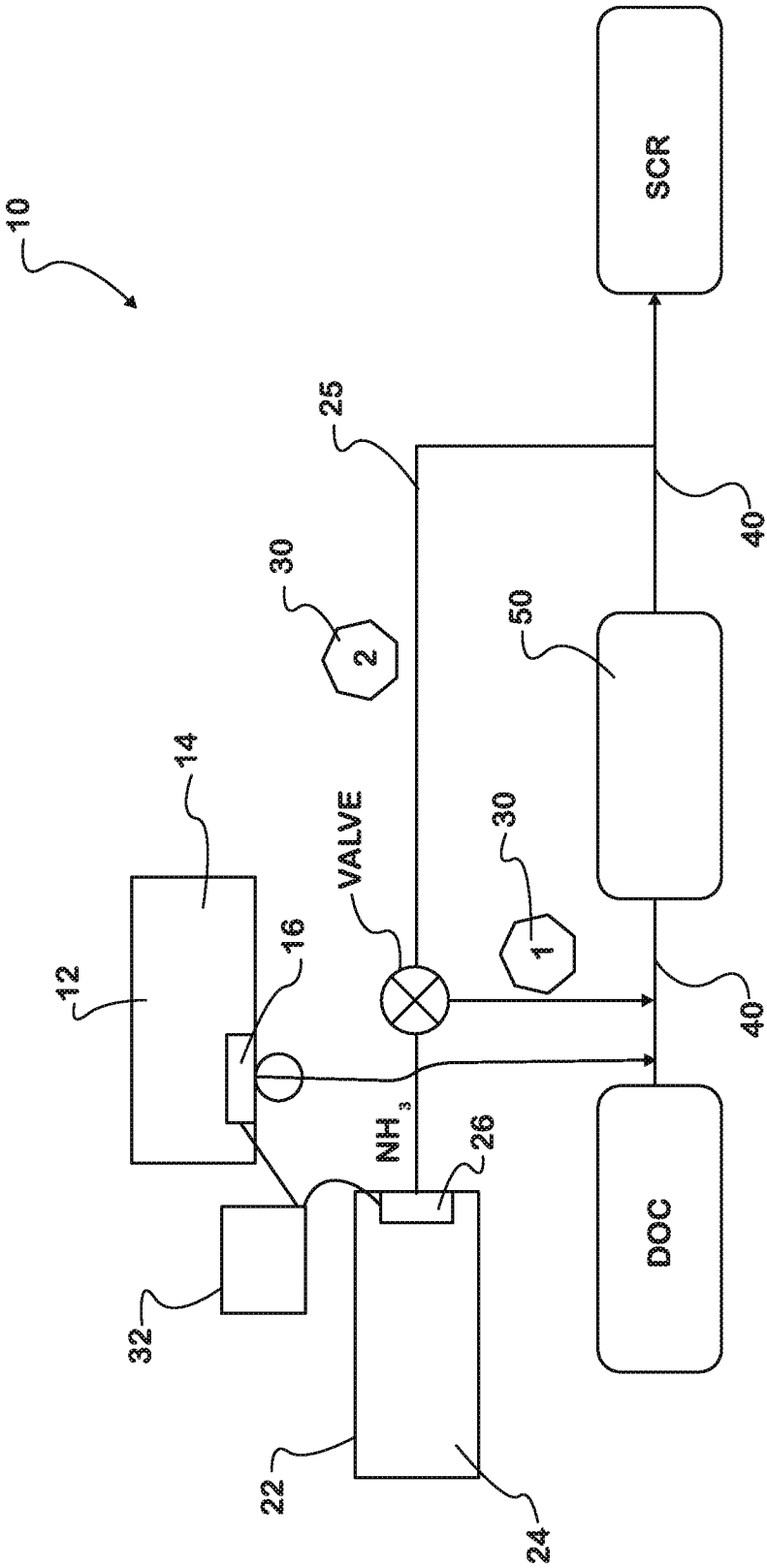


FIG. 1

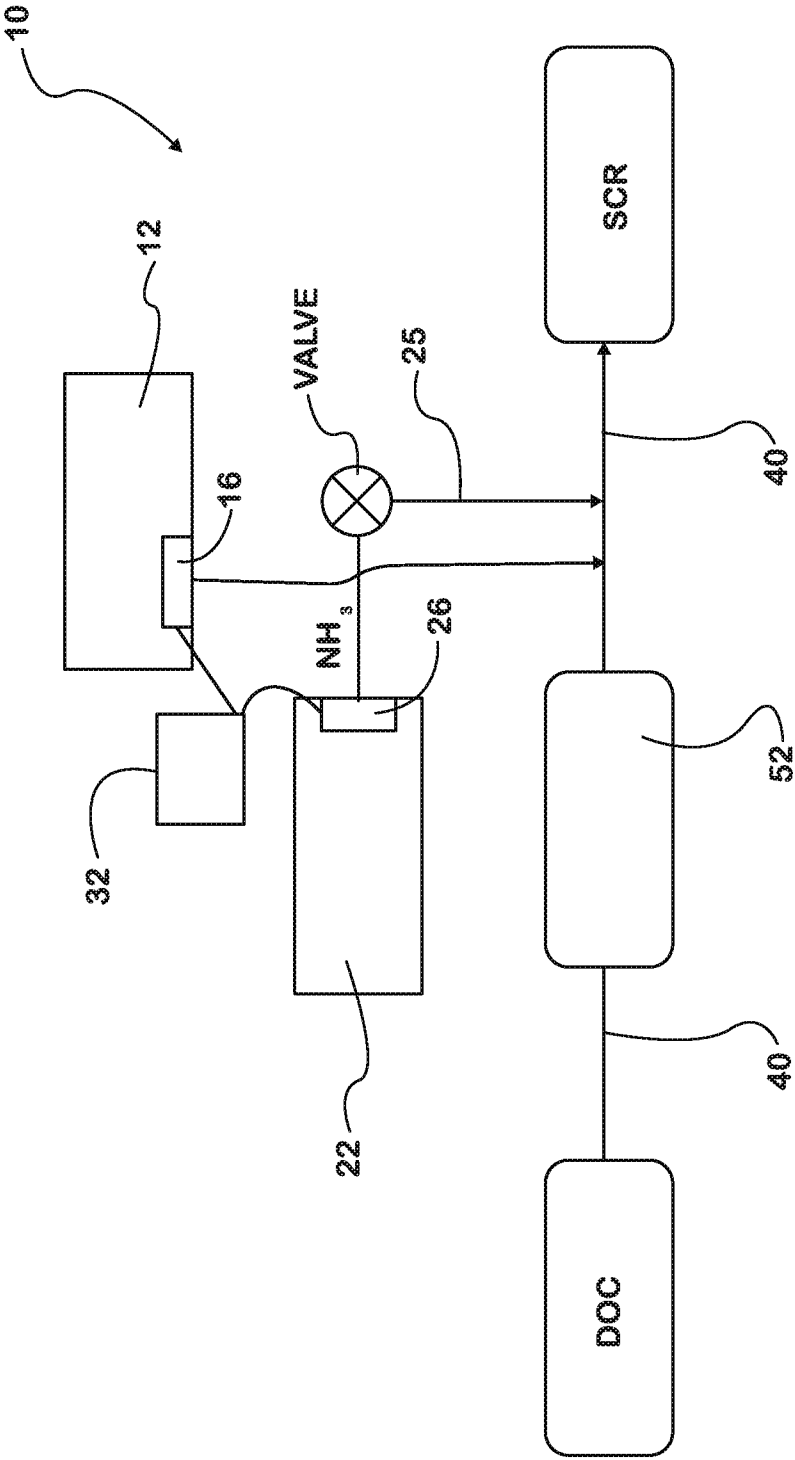


FIG. 2

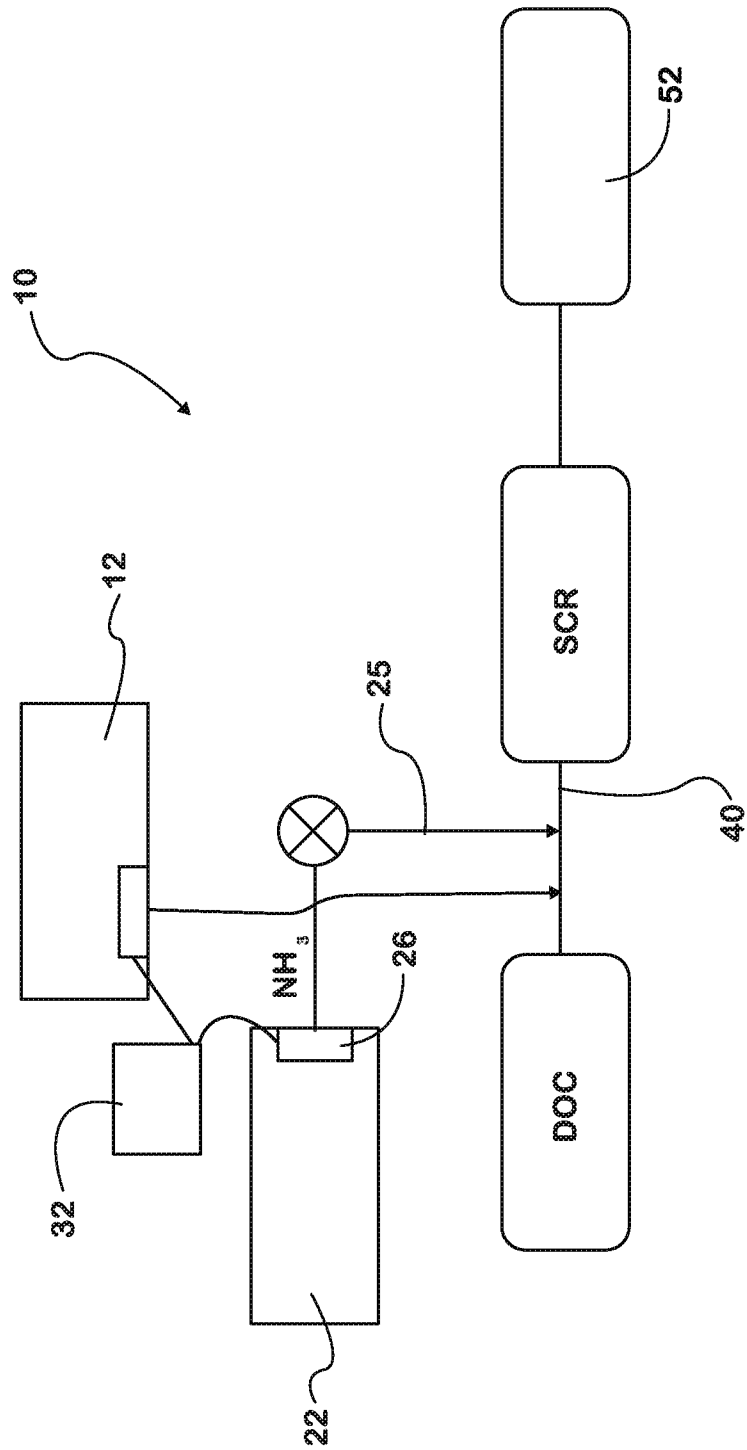


FIG. 3

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US2012/033975

A. CLASSIFICATION OF SUBJECT MATTER

IPC(8) - B01D 53/90 (2012.01)

USPC - 60/295

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC(8) - B01D 53/34, 53/56, 53/90, 53/92; F01N 3/08 (2012.01)

USPC - 60/272,274,282,286,295,299,301; 422/168,169,170,172; 423/212,213.2,213.7,235,239.1

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

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

PatBase

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X -- Y	US 2009/0035194 A1 (ROBEL et al) 05 February 2009 (05.02.2009) entire document	11-15 ----- 1-10
Y	WO 2010/110669 A1 (GISMERVIK) 30 September 2010 (30.09.2010) entire document	1-10

☐ Further documents are listed in the continuation of Box C.

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

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

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

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

"&" document member of the same patent family

Date of the actual completion of the international search

25 June 2012

Date of mailing of the international search report

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