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(54) Title: METHOD FOR HEATING SOLID AMMONIA TO RELEASE GASEOUS AMMONIA IN EXHAUST AFTER TREATMENT SYSTEM

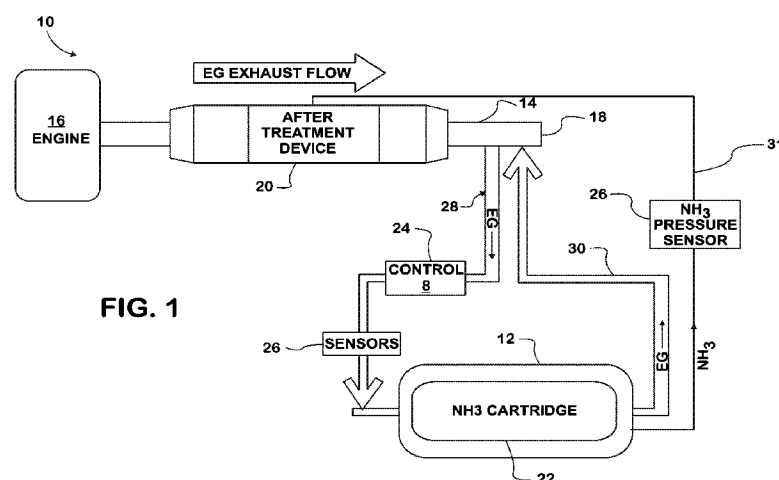


FIG. 1

(57) Abstract: A method for heating solid ammonia (NH₃) in a main unit (12) to deliver gaseous ammonia into the exhaust gas (EG) downstream of an engine (16) includes the steps of diverting at least a portion of the exhaust gas from the exhaust gas passageway (14), fluidly communicating the exhaust gas on a delivery line (28) from the exhaust gas passageway to the main unit, heating the solid ammonia with the exhaust gas, and fluidly communicating the exhaust gas on a return line (30) from the main unit to the exhaust gas passageway.

METHOD FOR HEATING SOLID AMMONIA TO RELEASE GASEOUS AMMONIA IN EXHAUST AFTERTREATMENT SYSTEM

BACKGROUND

[0001] Embodiments described herein relate to methods for heating a cartridge of ammonia salts to release ammonia into an exhaust aftertreatment system.

[0002] Diesel engine combustion results in the formation of nitrogen oxides, (NO_x), in the exhaust gas. An aftertreatment system is used to reduce oxides of Nitrogen (NO_x) emitted from the diesel engine. Nitrogen oxides can be reduced by ammonia (NH_3), which is injected into the exhaust gas stream, yielding N_2 , H_2O and CO_2 .

[0003] Typically, NH_3 is molecularly bonded to a solid host salt that is placed inside of a vessel called a main unit. The main unit is heated by hot engine coolant that is circulated around the main unit in a surrounding heating mantle. When heated, the host salt releases NH_3 molecules as gas, and the gaseous NH_3 is delivered to the exhaust gas stream where the nitrogen oxides are reduced.

[0004] The engine needs to provide an adequate amount of thermal energy for the host salt to release the gaseous NH_3 . Some engines may need to operate for a period of time to heat up the coolant. To decrease the NH_3 delivery time, an electrically heated start-up unit is often used to provide NH_3 to the exhaust gas stream until the engine coolant is hot enough to provide adequate thermal energy to the main unit.

[0005] Even when there is sufficient thermal energy for a reaction to occur, often only seven of the eight NH_3 molecules are released from the host salt because the engine coolant does not have adequate thermal energy to remove the eighth molecule. The eighth molecule often goes unused.

[0006] Some engines may not provide sufficient thermal energy for the exothermic NH_3 reaction to occur at all. Further, with developments in engine technology directed at increased efficiency, future engines may not run hot enough to support the exothermic NH_3 reaction.

[0007] Additionally, diverting engine coolant from other engine systems can cause a flow imbalance in the other engine systems. A flow imbalance of engine coolant can lead to engine system failures.

SUMMARY

[0008] A method for heating solid ammonia (NH_3) in a main unit to deliver gaseous ammonia into the exhaust gas downstream of an engine includes the steps of providing engine coolant that is dedicated only to heating the ammonia, heating the dedicated engine coolant at a heater, and fluidly communicating the engine coolant on a delivery line from the heater to the main unit. The method also includes the steps of heating the solid ammonia with the heated engine coolant, and fluidly communicating the engine coolant on a return line from the main unit to the heater.

[0009] Another method for heating solid ammonia (NH_3) to deliver gaseous ammonia into the exhaust gas downstream of an engine includes the steps of diverting at least a portion of the exhaust gas from the exhaust gas passageway, fluidly communicating the exhaust gas on a delivery line from the exhaust gas passageway to

the main unit, heating the solid ammonia with the exhaust gas, and fluidly communicating the exhaust gas on a return line from the main unit to the exhaust gas passageway.

[0010] In another method for heating ammonia (NH_3) in a main unit to deliver gaseous ammonia into exhaust gas downstream of an engine, the method includes the steps of providing engine oil or transmission oil, fluidly communicating the oil on a delivery line from the engine or the transmission to the main unit, and heating the solid ammonia with the heated oil. The method also includes the step of fluidly communicating the oil on a return line from the main unit to the engine or the transmission.

[0011] Another method for heating solid ammonia (NH_3) to deliver gaseous ammonia into exhaust gas downstream of an engine includes the steps of embedding an electric coil into the solid ammonia, heating the electric coil with an electrical heater, and attaching the electric coil to the electric heater with at least one wire.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012] FIG. 1 is a schematic showing the method of heating ammonia in a main unit with diverted exhaust gas.

[0013] FIG. 2 is a schematic showing the method of heating ammonia in the main unit with engine oil or transmission oil.

[0014] FIG. 3 is a schematic showing the method of heating ammonia in the main unit with dedicated coolant and an electric heater.

[0015] FIG. 4 is a schematic showing the method of heating ammonia in the main unit with dedicated coolant and a Peltier module.

[0016] FIG. 5 is a schematic showing the method of heating ammonia in the main unit with embedded electrical coils.

DETAILED DESCRIPTION

[0017] Referring to FIGs. 1-5, a method of heating a main unit 12 for delivering gaseous ammonia (NH_3) into an exhaust gas passageway 14 of a diesel engine 16 is indicated generally at 10, 110, 210, 310 and 410. The exhaust gas (EG) flows from the engine 16 to an outlet 18 through the exhaust gas passageway 14 in the direction indicated by the arrow. One or more aftertreatment devices 20 may be disposed on the exhaust gas passageway 14 between the engine 16 and the outlet 18 to treat the exhaust gas EG before being emitted at the outlet.

[0018] When the engine 16 combusts diesel, nitrogen oxides form and are released with the exhaust gas (EG). Nitrogen oxides, NO_x , are a pollutant that are reduced in the aftertreatment system by gaseous ammonia (NH_3) resulting in the emission of less harmful nitrogen, N_2 , water, H_2O , and carbon dioxide, CO_2 . The NH_3 is stored in a solid state in a NH_3 cartridge 22 inside of the main unit 12. When there is sufficient thermal energy, an exothermic reaction occurs, releasing gaseous NH_3 that can be delivered to the exhaust gas.

[0019] The delivery of NH_3 may be implemented by software on the vehicle, such as at a control unit 24, however other controllers are possible. At least one sensor 26 may sense the NH_3 gas outlet pressure at or near the NH_3 cartridge 22, such as at the outlet or downstream of the main unit 12. If the sensor 26 senses that the system

requires NO_x reduction, the control unit 24 may increase the amount of thermal energy from an alternative source of thermal energy, as will be discussed below. The system will dose NH₃ to the exhaust passageway 14 as long as the main unit 12 NH₃ outlet pressure is in the range of about 1.8 – 2.5 bar abs. The exhaust gas EG pressure is typically in the range of 1.4-1.5 bar abs.

[0020] The methods 10, 110, 210, 310 and 410 of FIGs. 1-5 all use alternative sources of thermal energy to heat the main unit 12 as compared to the conventional source, which is engine coolant that is shared with other engine systems to heat the main unit 12. Although the following description will be directed to a method for heating the main unit 12 in a vehicle aftertreatment system, the method 10, 110, 210, 310 and 410 of FIGs. 1-5 can be used with any diesel engine 16 that emits NO_x.

[0021] Referring to FIG. 1 and the method of heating 10, the alternative source of thermal energy is exhaust gas EG diverted from the exhaust gas passageway 14. The exhaust gas EG may be diverted downstream of the aftertreatment device 20 so that the exhaust gas is less corrosive and free of unburned hydrocarbons and other particulate matter relative to the exhaust gas upstream of the aftertreatment device. The exhaust gas EG flows through a delivery line 28 to the main unit 12.

[0022] At the main unit 12, the exhaust gas EG surrounds the NH₃ cartridge 22 and heats the ammonia salt contained in the cartridge. The temperature of the NH₃ cartridge 22 may exceed the minimum temperature to release gaseous ammonia NH₃, and may be about 150-degrees Celsius, which is sufficient thermal energy to release the eighth molecule of gaseous NH₃ from the ammonia salt. After circulating around the NH₃ cartridge 22, the exhaust gas EG is cooled and flows back to the exhaust gas passageway 14 on a return line 30. The gaseous NH₃ may also flow to the exhaust gas passageway 14 on the return line 30, or alternatively, may be delivered to the exhaust

gas passageway on a separate NH_3 line 31. Using exhaust gas EG as the thermal source, engine coolant systems are not affected.

[0023] Referring to FIG. 2, the method of heating 110 employs engine oil or transmission oil (oil) as the alternative source of thermal energy. The heated oil is delivered from the engine or transmission 16 and flows through a delivery line 128 to the main unit 12, where the oil flows around the NH_3 cartridge 22. The oil heats the ammonia salt contained in the NH_3 cartridge 22 to release gaseous ammonia. The cooled oil flows from the main unit 12 back to the engine or transmission 16 on the return line 130. The gaseous ammonia NH_3 released from the NH_3 cartridge 22 is delivered to the aftertreatment device 20 on the exhaust gas passageway 14.

[0024] It is possible that transmission oil may be used in applications where the engine is not hot enough to provide adequate thermal energy, or where diverting engine coolant may lead to system imbalances. Further, since oil is used as the thermal source, engine coolant systems are not affected by the method 110 of heating the NH_3 cartridge 22. It is possible that both engine oil and transmission oil can be used.

[0025] Referring now to the method of heating 210 of FIG. 3, the alternative source of energy is coolant (CL) provided on a dedicated coolant circuit. The coolant CL is coolant that is not used for other engine systems, but is coolant that is used only to heat the NH_3 cartridge. The dedicated coolant CL is not connected to the engine's 16 coolant circuit, however the hardware to circulate the coolant may be mounted on the engine, the chassis, or anywhere else. The coolant CL is heated at a heater 232, such as an electrical heater, and from the heater, the coolant is in fluid communication with the main unit 12 on a delivery line 228. Temperatures may exceed about 150-degrees Celsius at the main unit 12, which may release the eighth molecule of NH_3 .

from the NH_3 cartridge 22. The cooled coolant CL flows back to the heater 232 on a return line 230. The gaseous NH_3 released from the cartridge 22 is delivered to the exhaust gas passageway 14 on line 31.

[0026] The method of heating 310 of FIG. 4 employs dedicated engine coolant (CL) that is heated thermoelectrically. The coolant CL is coolant that is not used for other engine systems, but is used only to heat the NH_3 cartridge. The coolant CL is heated thermoelectrically at a thermo-module 332, for example a thermo-module that uses the Peltier Effect to heat the coolant CL. The heated coolant CL is in fluid communication with the main unit 12 on a delivery line 328 from the thermo-module 332 to the main unit. The heated coolant provides sufficient thermal energy for gaseous ammonia to be released and to be delivered to the exhaust gas passageway 14. A return line 330 provides the fluid communication of the coolant CL from the main unit 12 back to the thermo-module 332.

[0027] Referring now to FIG. 5, the method of heating 410 employs electrical coils 434 embedded in the host salt of the NH_3 cartridge 22. The electrical coils 434 are electrically connected with at least two wires 436, 438 to an electric heating source 432. The embedded coils 434, heated by the heating source 432, provide sufficient thermal energy to release gaseous ammonia NH_3 , which is deliverable to the exhaust gas passageway 14.

[0028] The methods of FIGs. 1-5 may allow the size of the main unit 12 to be reduced since the alternative sources of thermal energy may be more efficient than the conventional engine coolant. Further, the methods of FIGs. 1-5 may release the eighth molecule of the NH_3 to which can be used to convert NO_x . Further still, the start-up unit that is often used with the conventional engine coolant can be eliminated.

What is claimed is:

1) A method for heating solid ammonia (NH_3) in a main unit to deliver gaseous ammonia into exhaust gas downstream of an engine, the method comprising:

providing engine coolant that is dedicated only to heating the solid ammonia;

heating the dedicated engine coolant at a heater;

fluidly communicating the engine coolant on a delivery line from the heater to the main unit;

heating the solid ammonia with the heated engine coolant; and

fluidly communicating the engine coolant on a return line from the main unit to the heater.

2) The method of claim 1 wherein the heated engine coolant heats the solid ammonia to a temperature of at least about 150-degrees Celsius for the eighth molecule of gaseous ammonia to be released from the solid ammonia..

3) The method of claim 1 wherein the heater is a thermo-electric heater that uses the Peltier effect to heat the engine coolant.

4) The method of claim 1 wherein the heater is an electric heater.

5) The method of claim 1 further comprising storing the solid ammonia inside an NH₃ cartridge that is disposed inside of the main unit.

6) The method of claim 1 further comprising controlling the temperature of the engine coolant with a control unit.

7) The method of claim 1 further comprising sensing the temperature of the engine coolant with a sensor.

8) A method for heating solid ammonia (NH₃) in a main unit to deliver gaseous ammonia into exhaust gas in an exhaust gas passageway downstream of an engine, the method comprising:

diverting at least a portion of the exhaust gas from the exhaust gas passageway;

fluidly communicating the exhaust gas on a delivery line from the exhaust gas passageway to the main unit;

heating the solid ammonia with the exhaust gas; and

fluidly communicating the exhaust gas on a return line from the main unit to the exhaust gas passageway.

9) The method of claim 8 wherein the heated exhaust gas heats the solid ammonia to a temperature of at least about 150-degrees Celsius for the eighth molecule of gaseous ammonia to be released from the solid ammonia..

10) The method of claim 8 further comprising the step of diverting the exhaust gas downstream of an aftertreatment device.

11) The method of claim 10 further comprising the step of returning the exhaust gas downstream of the aftertreatment device.

12) The method of claim 8 further comprising storing the solid ammonia inside an NH₃ cartridge that is disposed inside of the main unit.

13) A method for heating solid ammonia (NH₃) in a main unit to deliver gaseous ammonia into exhaust gas downstream of an engine, the method comprising:

providing at least one of engine oil and transmission oil;

fluidly communicating the oil on a delivery line from the at least one of the engine and the transmission to the main unit;

heating the solid ammonia with the heated oil; and

fluidly communicating the oil on a return line from the main unit to the at least one of the engine and the transmission.

14) The method of claim 13 further comprising storing the solid ammonia inside an NH₃ cartridge that is disposed inside of the main unit.

15) The method of claim 13 further comprising controlling the temperature of the oil with a control unit.

16) The method of claim 13 further comprising sensing the temperature of the oil with a sensor.

17) A method for heating solid ammonia (NH_3) to deliver gaseous ammonia into exhaust gas downstream of an engine, the method comprising:

embedding an electric coil into the solid ammonia;

heating the electric coil with an electrical heater; and

attaching the electric coil to the electric heater with at least one wire.

18) The method of claim 17 further comprising embedding the electric coil inside of an NH_3 cartridge.

19) The method of claim 17 further comprising controlling the temperature of the embedded coil with a control unit.

20) The method of claim 17 further comprising sensing the temperature of the solid ammonia with a sensor.

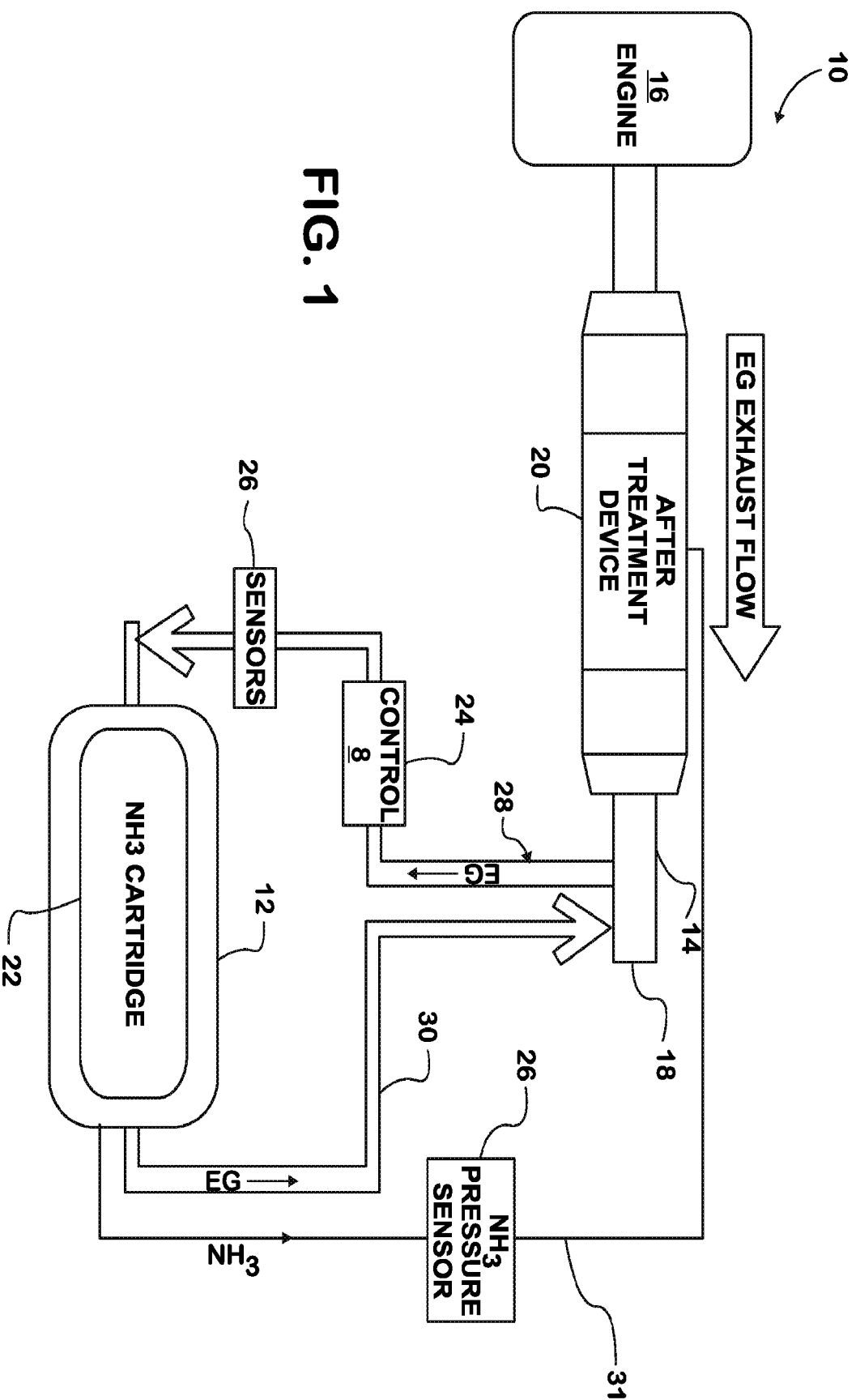


FIG. 1



FIG. 2

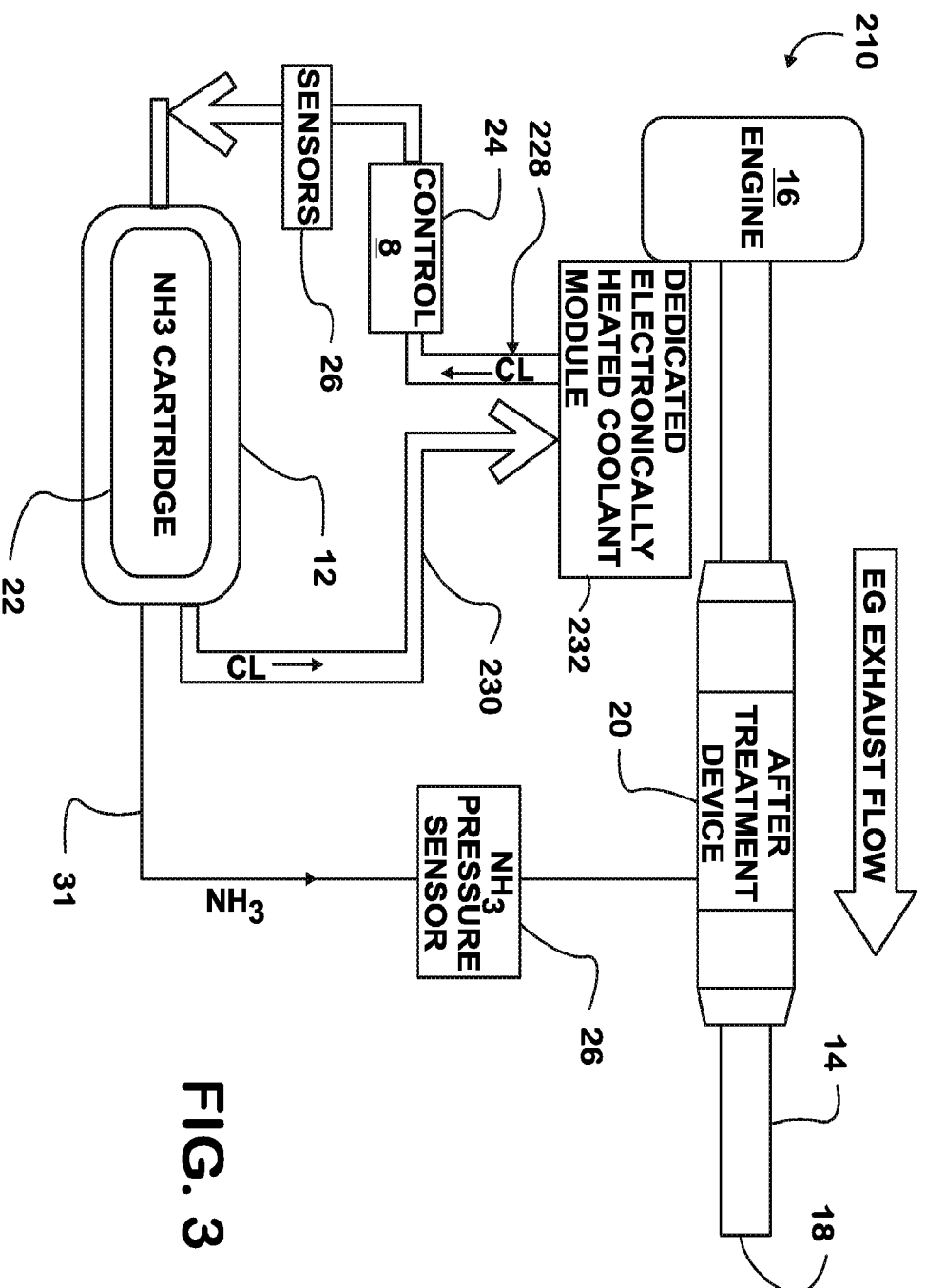


FIG. 3

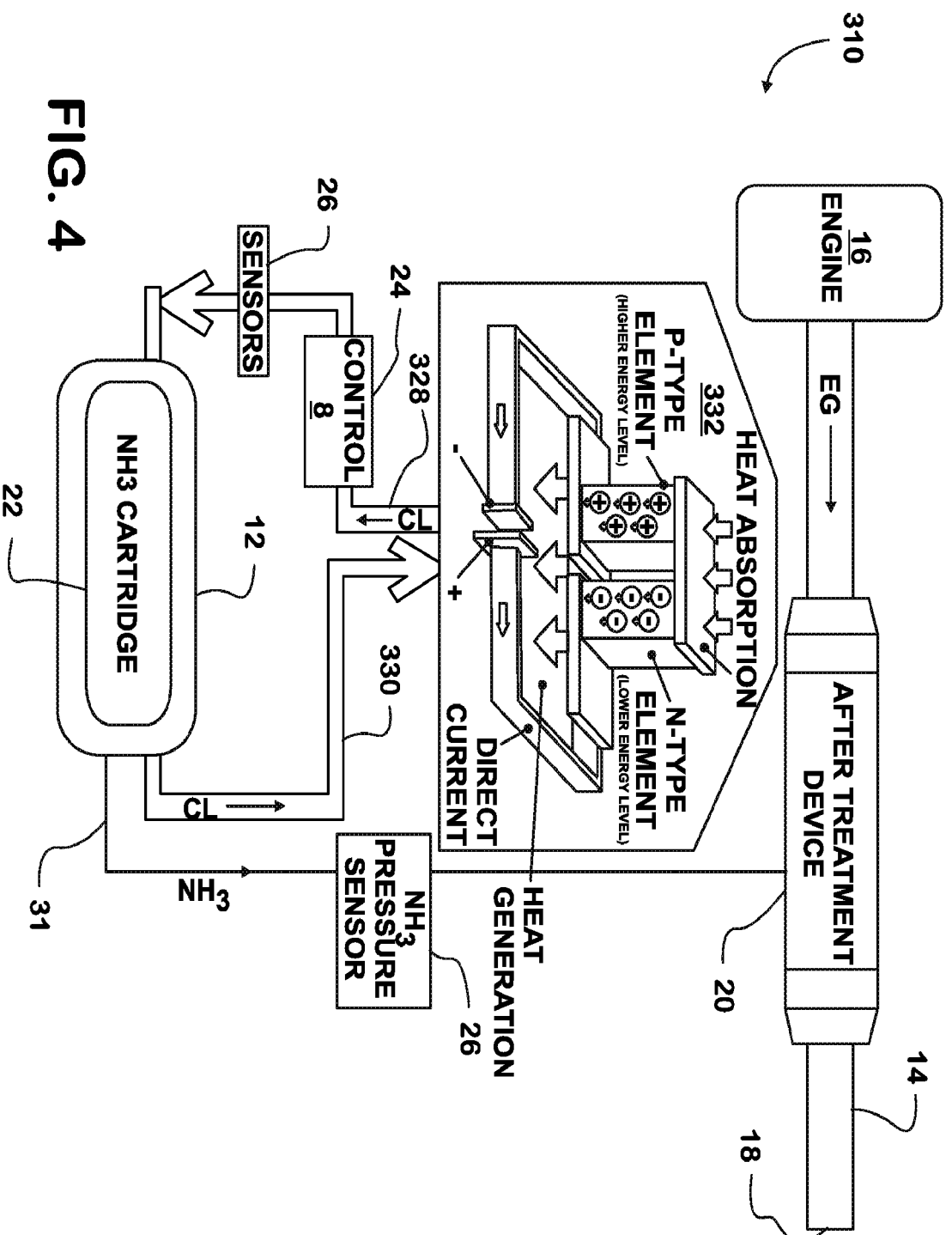


FIG. 4

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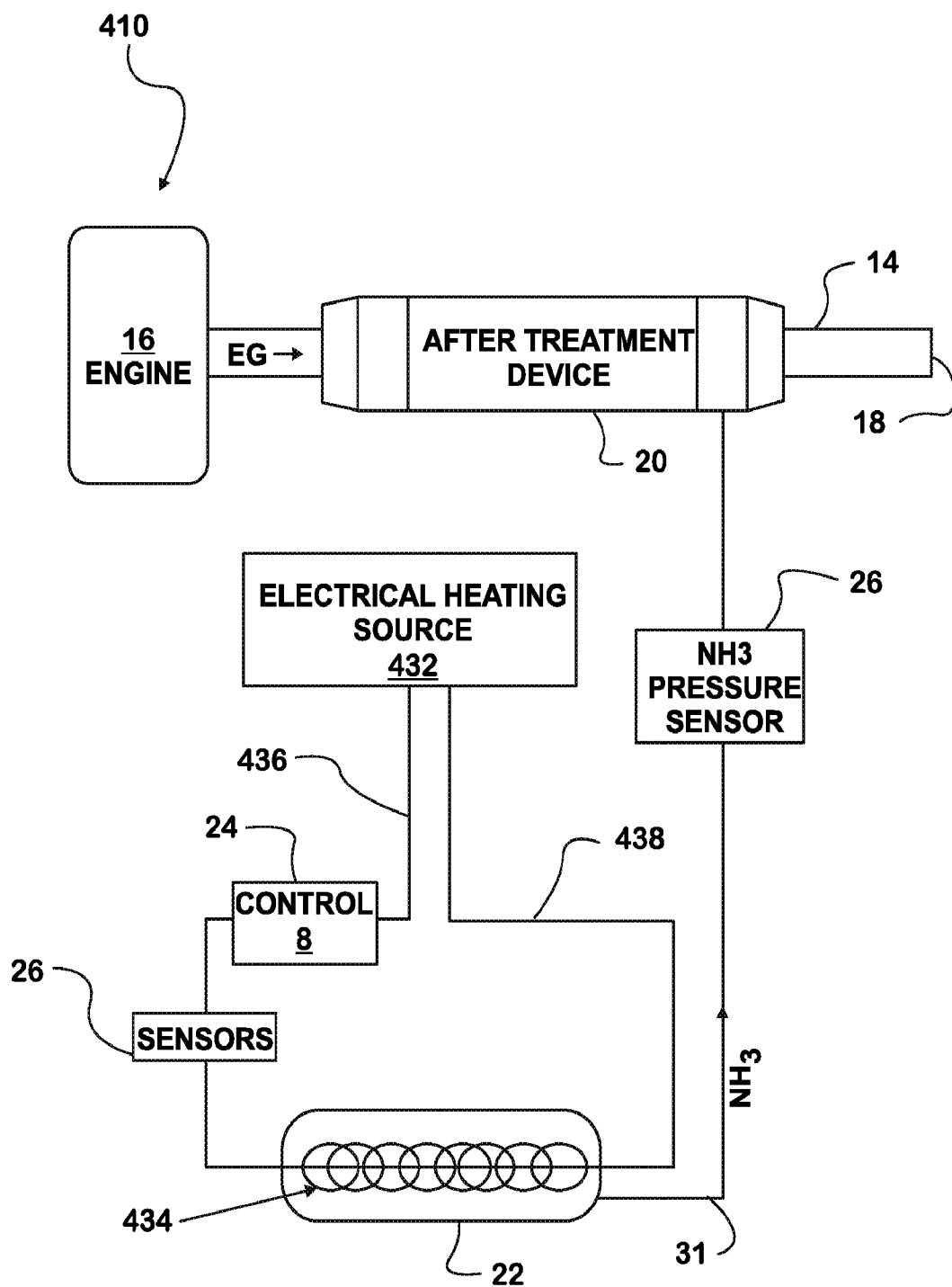


FIG. 5

INTERNATIONAL SEARCH REPORT

PCT/US2011/044022

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A. CLASSIFICATION OF SUBJECT MATTER

IPC(8) - F01N 3/02 (2011.01)

USPC - 60/285

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) - F01N 3/02 (2011.01)

USPC - 60/276, 277, 282, 284, 285, 286

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, Google Scholar

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 2004/0206069 A1 (TUMATI et al) 21 October 2004 (21.10.2004) entire document	1-20
Y	US 2010/0055508 A1 (RENN) 04 March 2010 (04.03.2010) entire document	1-20

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

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