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(54) **NON-ENGINE BASED EXHAUST COMPONENT RAPID AGING SYSTEM**

(76) Inventors: **Joseph M. Adams**, Pendleton, IN (US); **Michael K. Bellis**, Grand Blanc, MI (US); **Russell P. Richmond**, Clifford, MI (US)

Correspondence Address:
Vincent A. Cichosz, Delphi Technolegies
Legal Staff, Mail Code 480-414-420
P.O. Box 5052
Troy, MI 48007-5052 (US)

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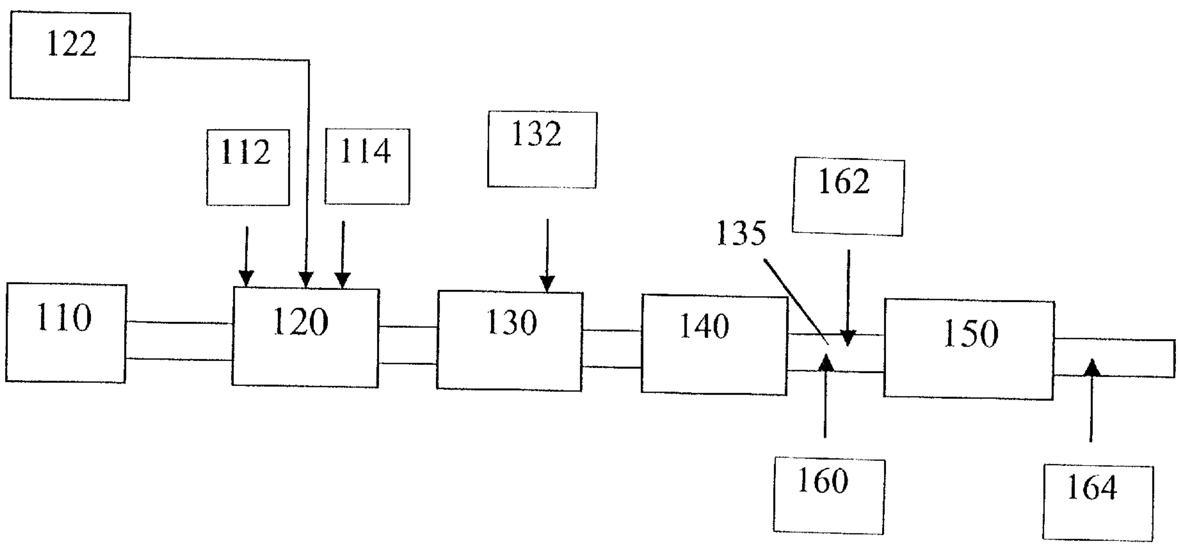
(57) **ABSTRACT**

A non-engine based exhaust component rapid aging system comprises a combustor in fluid communication with an air and a fuel supply; and a first emission analyzer in fluid communication with said combustor, wherein said first emission analyzer and said combustor are further capable of being disposed in fluid communication with an exhaust component; and wherein said non-engine based exhaust component rapid aging system is capable of operation at an air to fuel ratio of about 7 to about 16.

The non-engine based rapid aging method comprises combusting fuel with air to produce exhaust gas; controlling a temperature of said exhaust gas; supplying said exhaust gas to said exhaust component; and analyzing a composition of said exhaust gas.



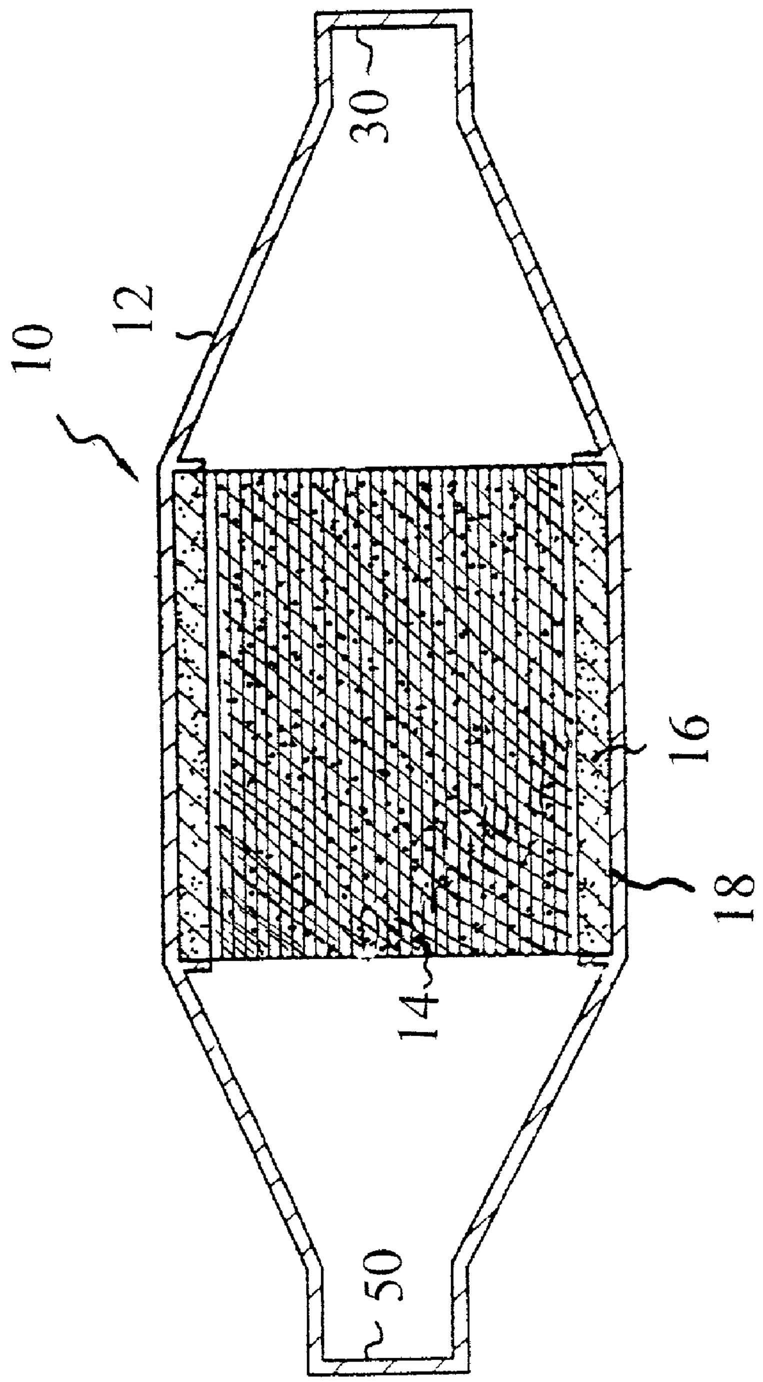


FIG. 1

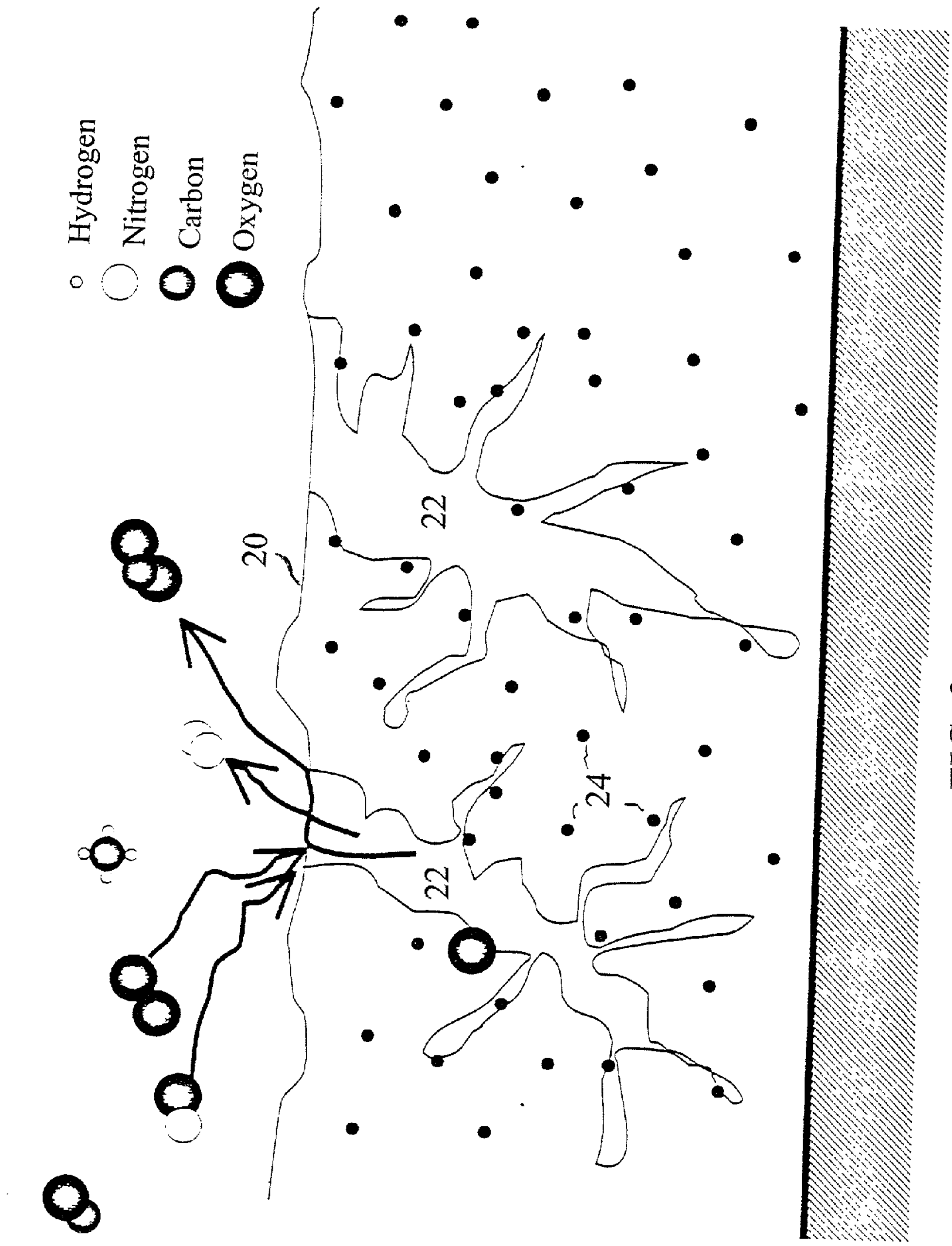


FIG. 2

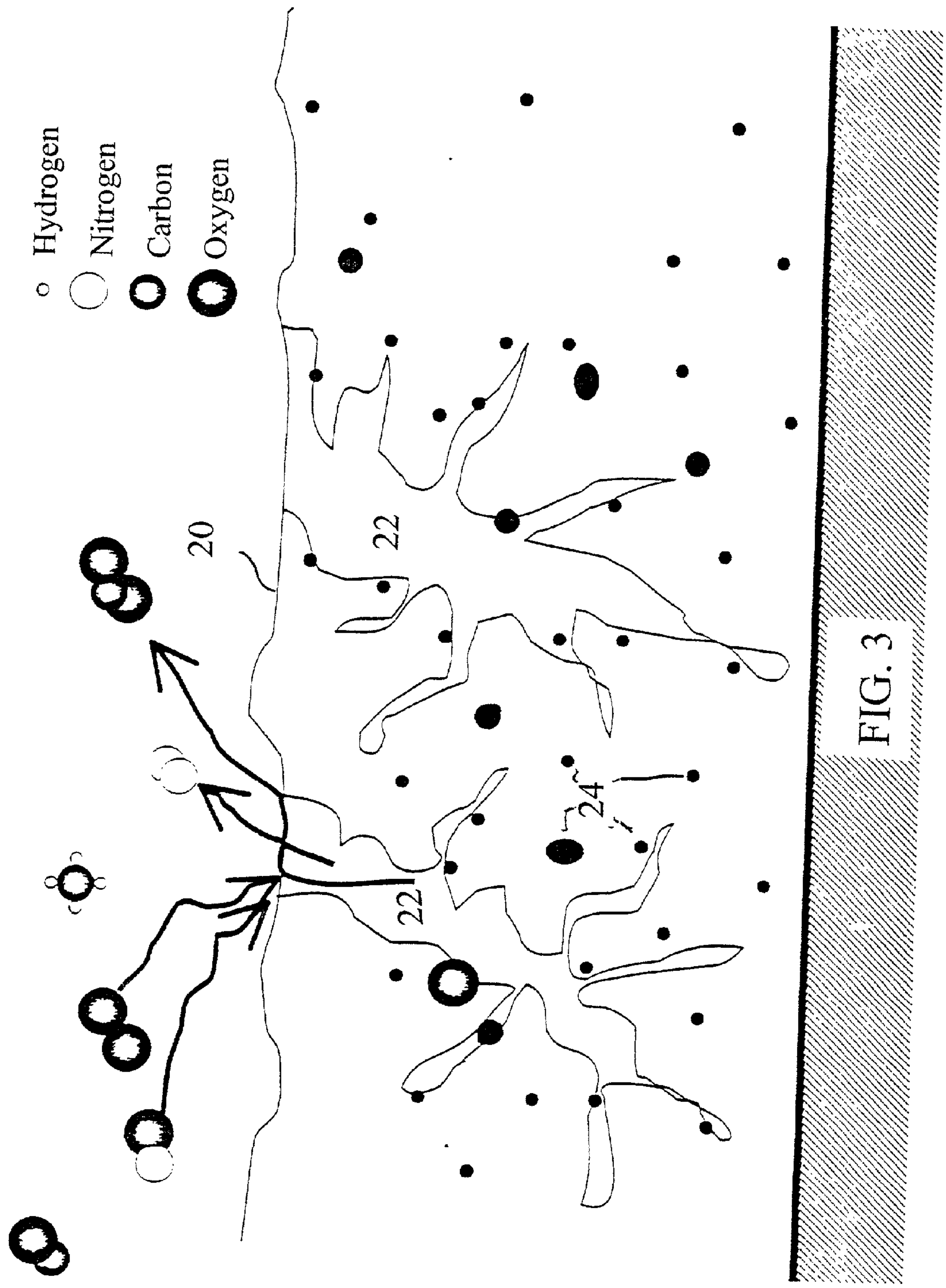


FIG. 3

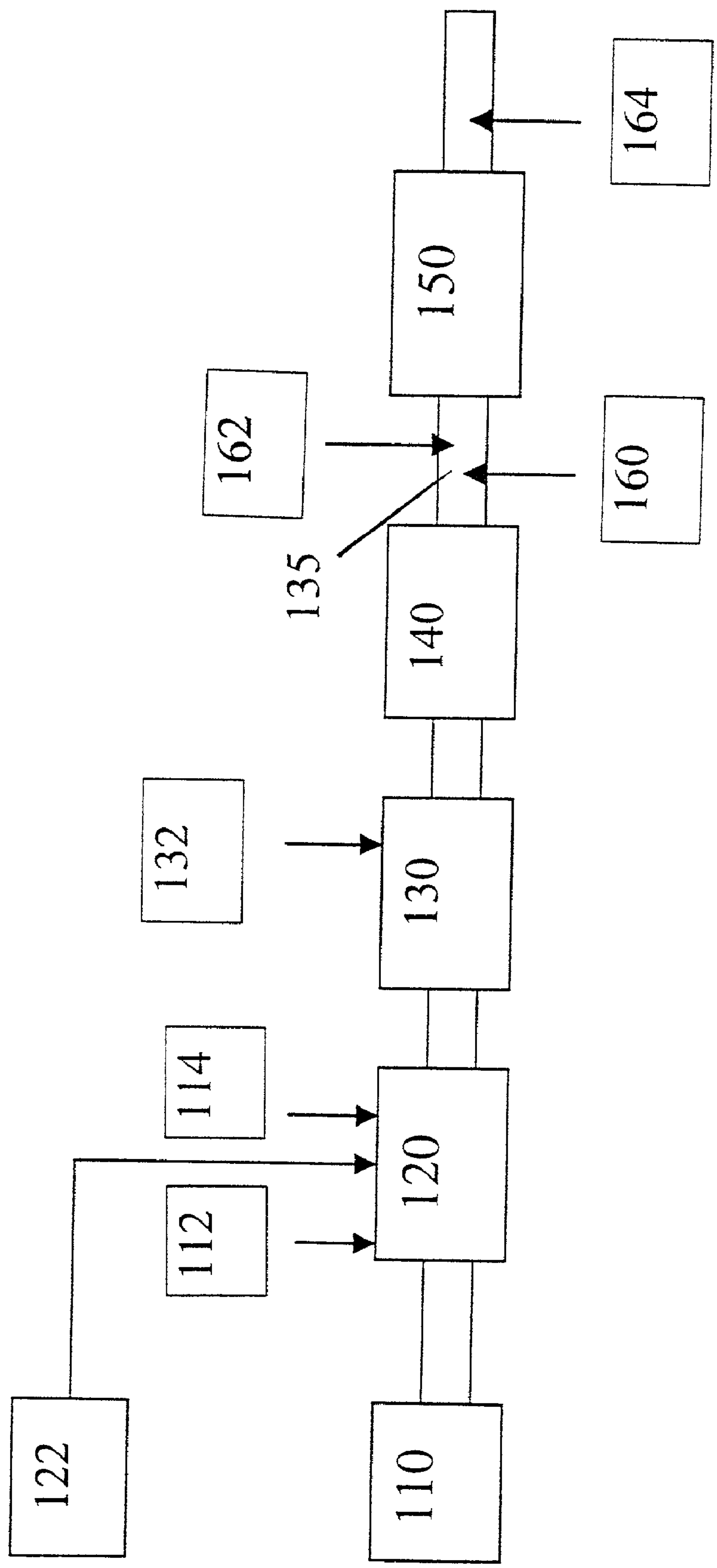


FIG. 4

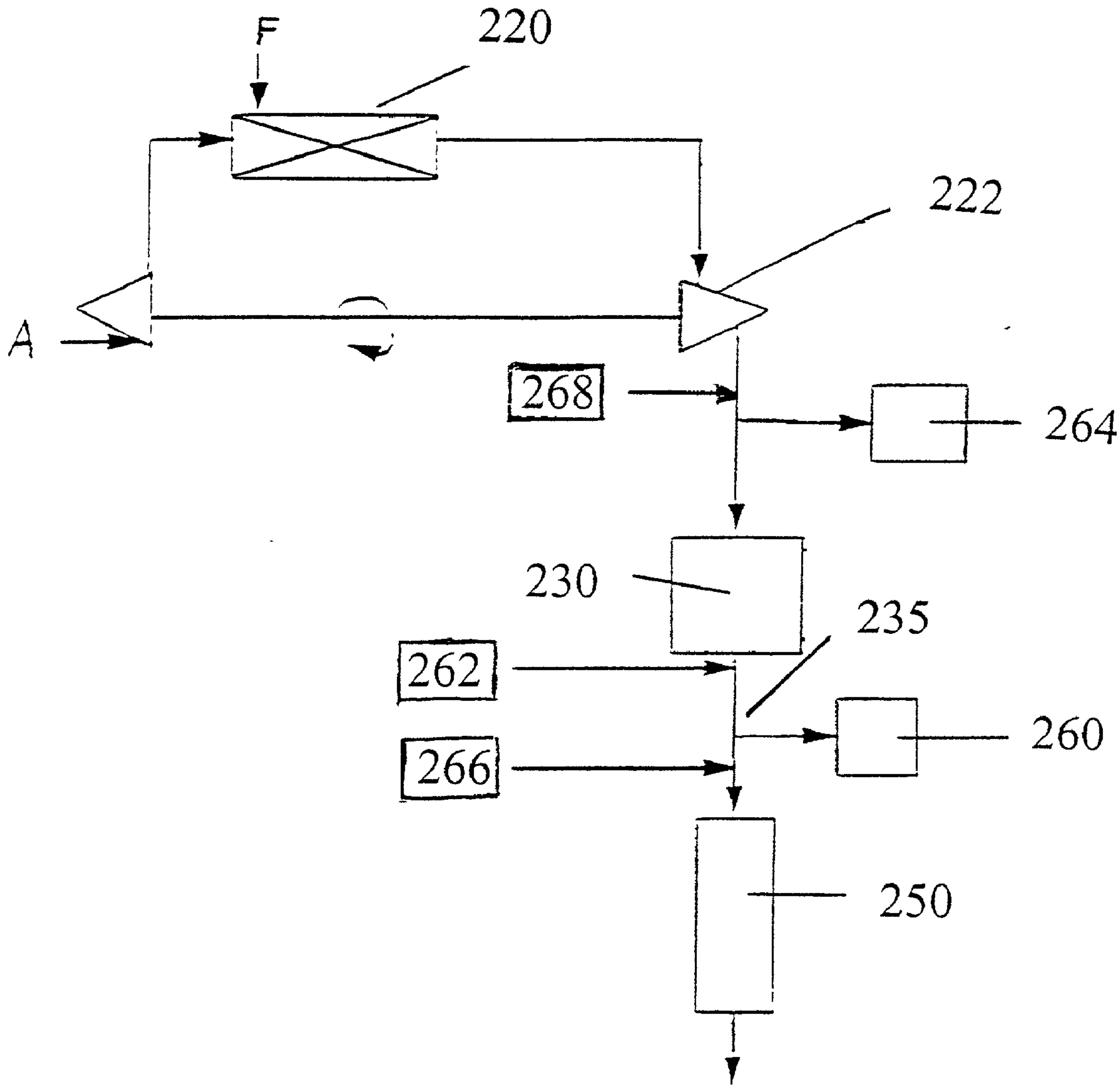


FIG. 5

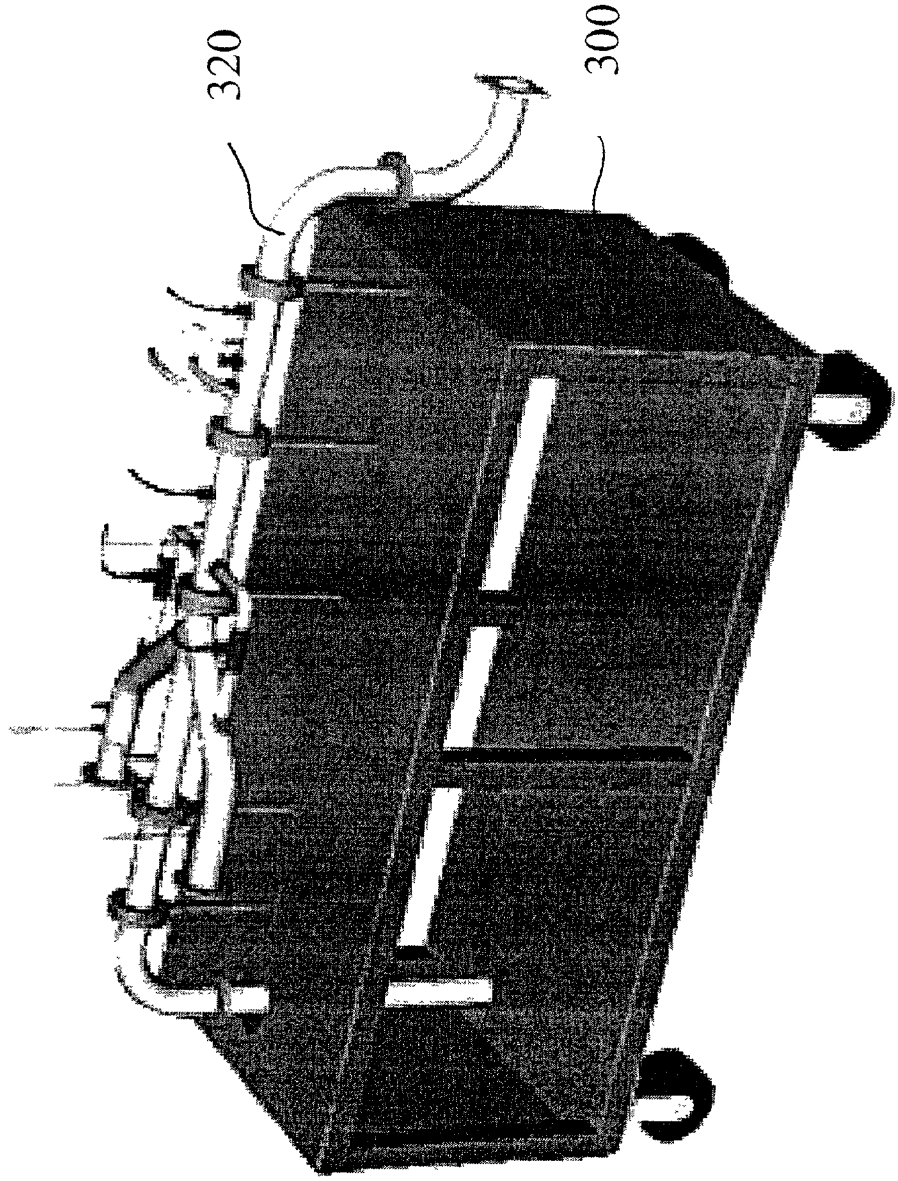


FIG. 6

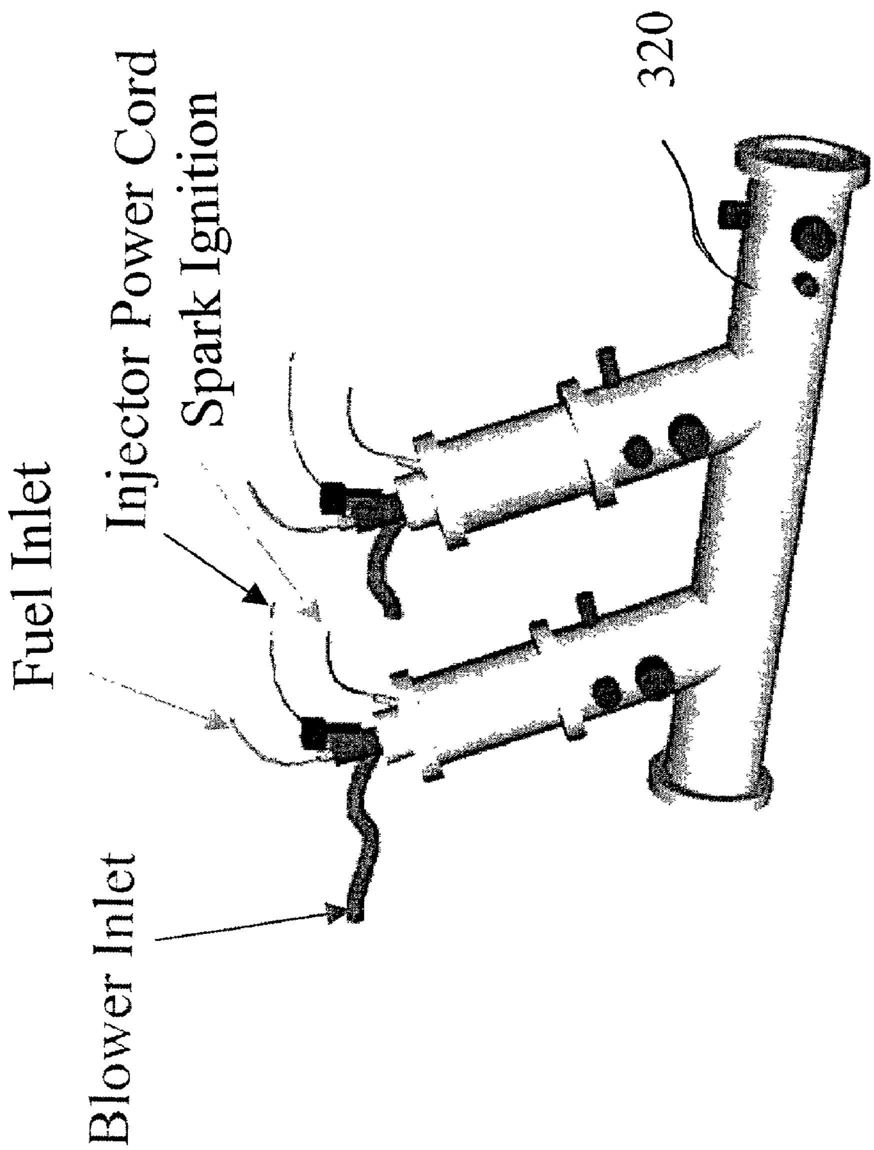
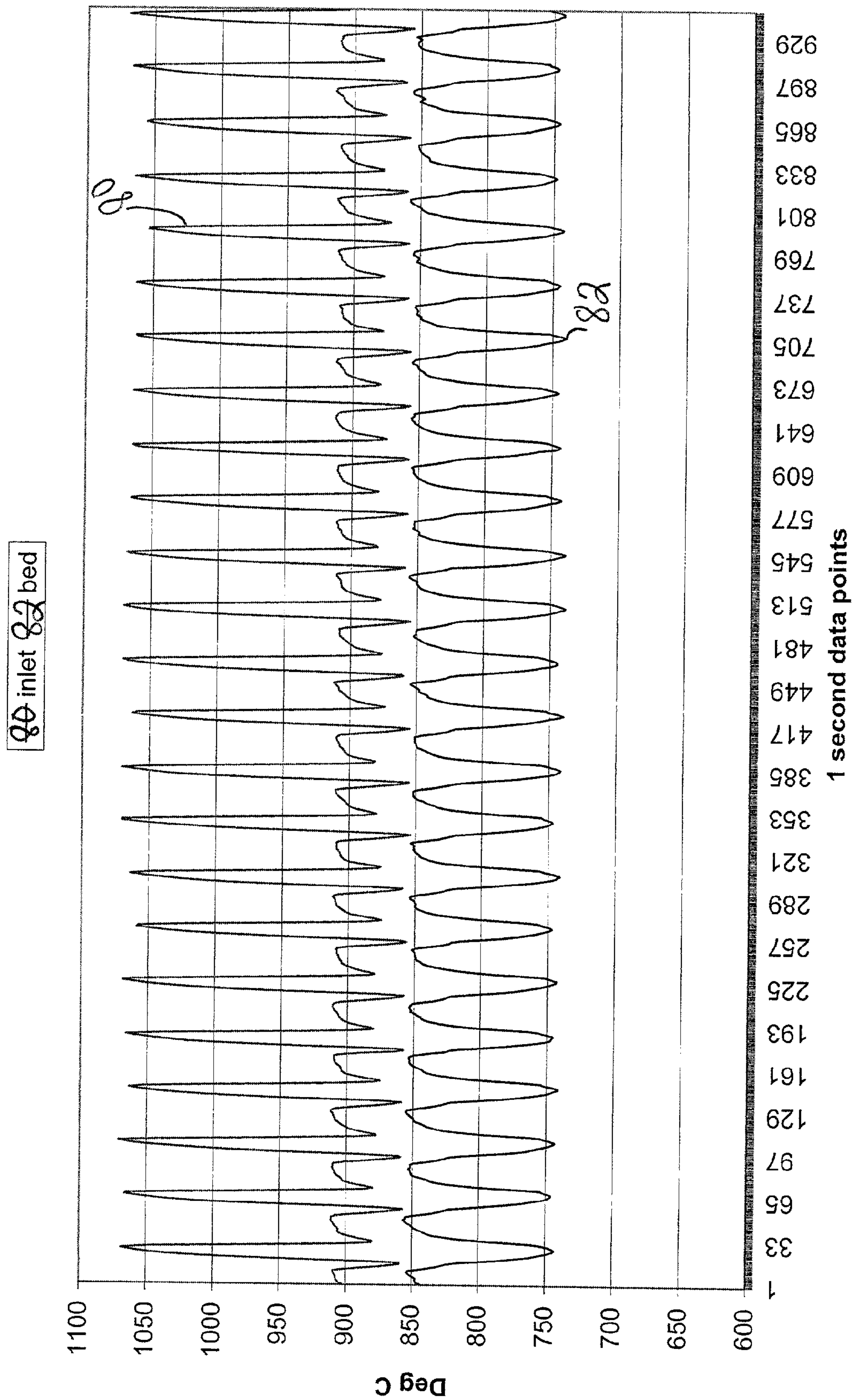

Fuel Inlet
Injector Power Cord
Spark Ignition
320
Blower Inlet

FIG. 7

Figure 8


80 inlet 82 bed
Deg C
1100
1050
1000
950
900
850
800
750
700
650
600
1 second data points
1
33
65
97
129
161
193
225
257
289
321
353
385
417
449
481
513
545
577
609
641
673
705
737
769
801
833
865
897
929
80
82

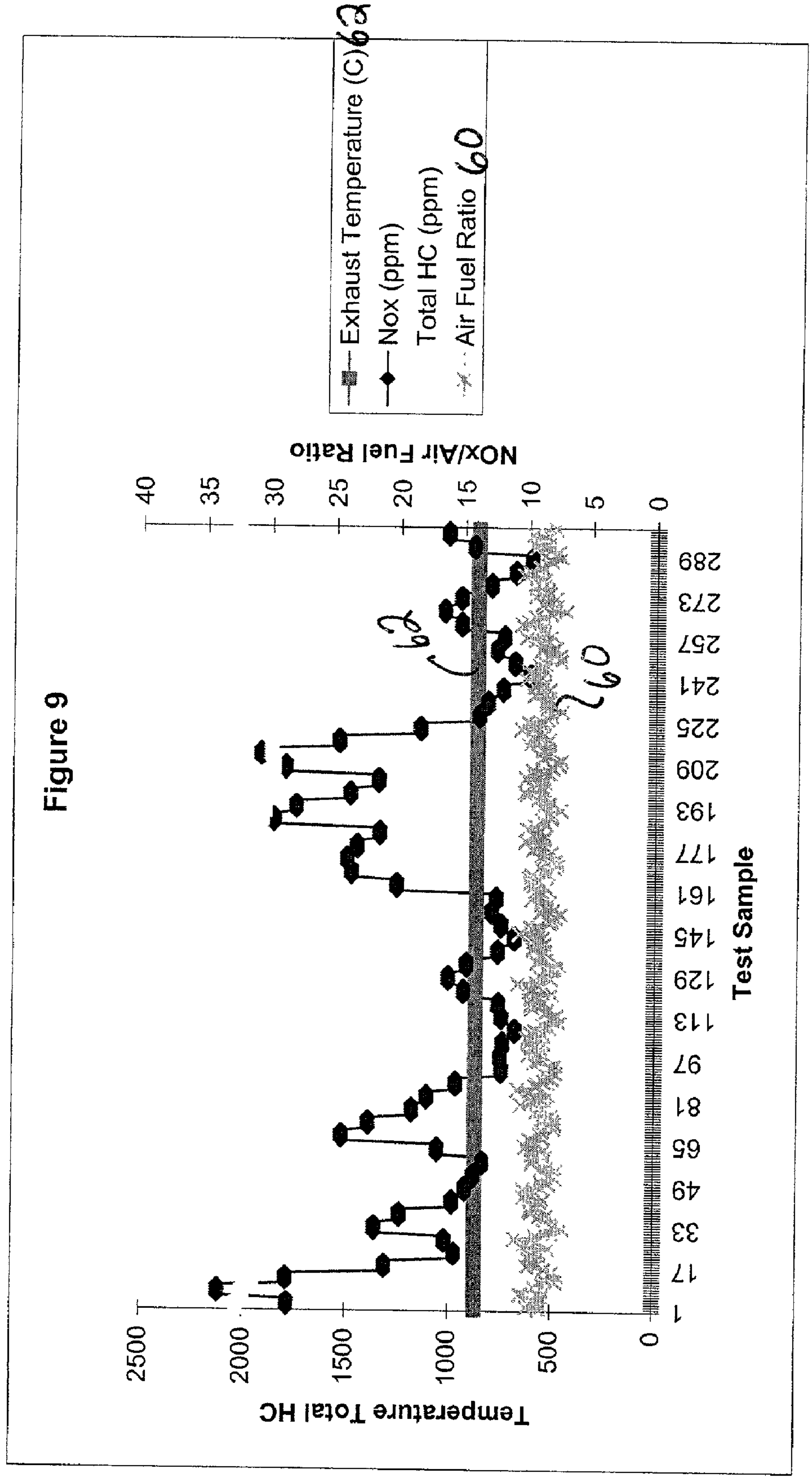
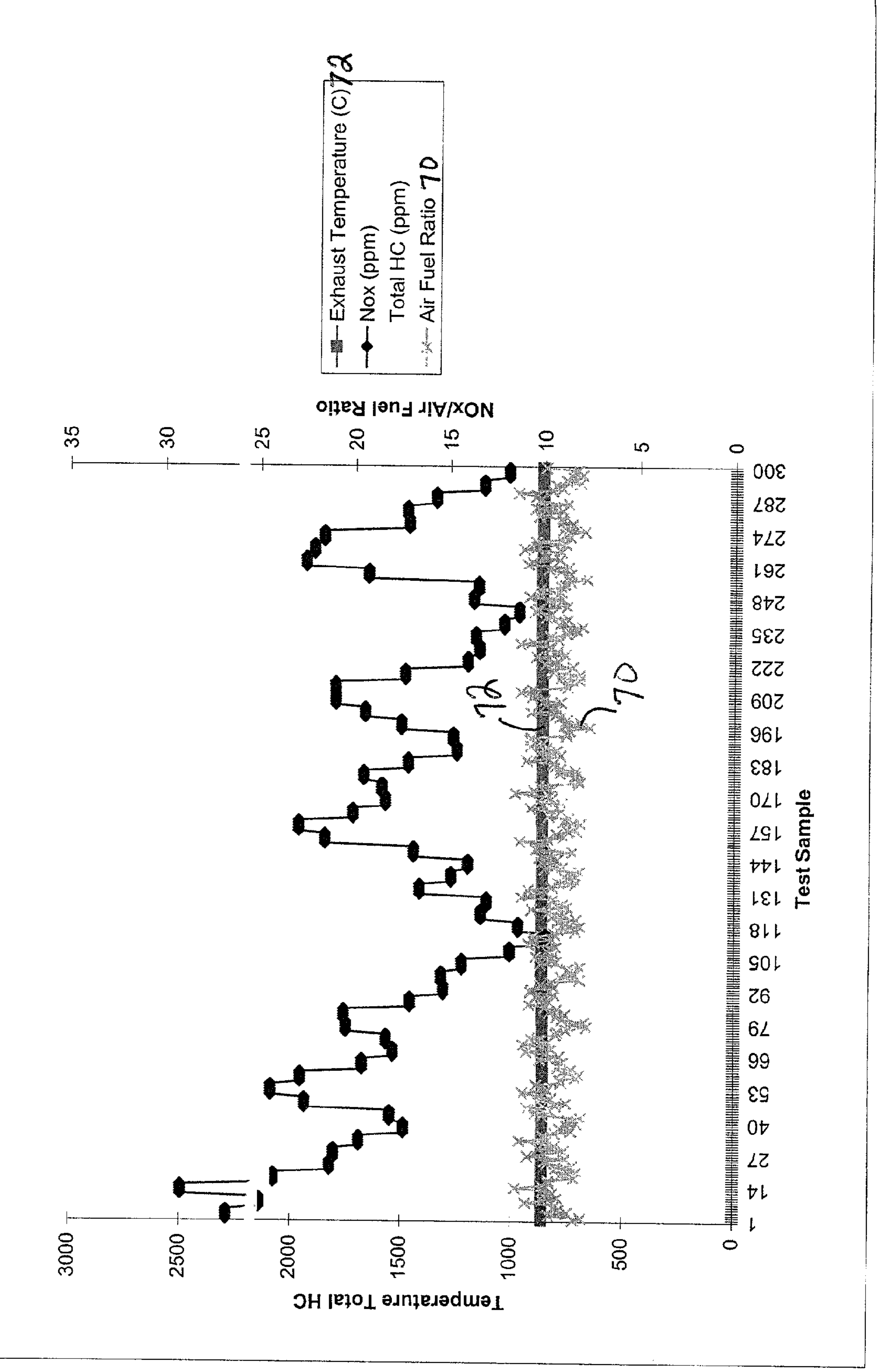

Exhaust Temperature (C) 62
Nox (ppm)
Total HC (ppm)
Air Fuel Ratio 60
NOX/Air Fuel Ratio
40 35 30 25 20 15 10 5 0
Temperature Total HC
2500 2000 1500 1000 500 0
1 17 33 49 65 81 97 113 129 145 161 177 193 209 225 241 257 273 289
Test Sample
62
60

Figure 9



Exhaust Temperature (C) 72
Nox (ppm)
Total HC (ppm)
Air Fuel Ratio 70
NOX/Air Fuel Ratio
Temperature Total HC
Test Sample
72
70

Figure 10

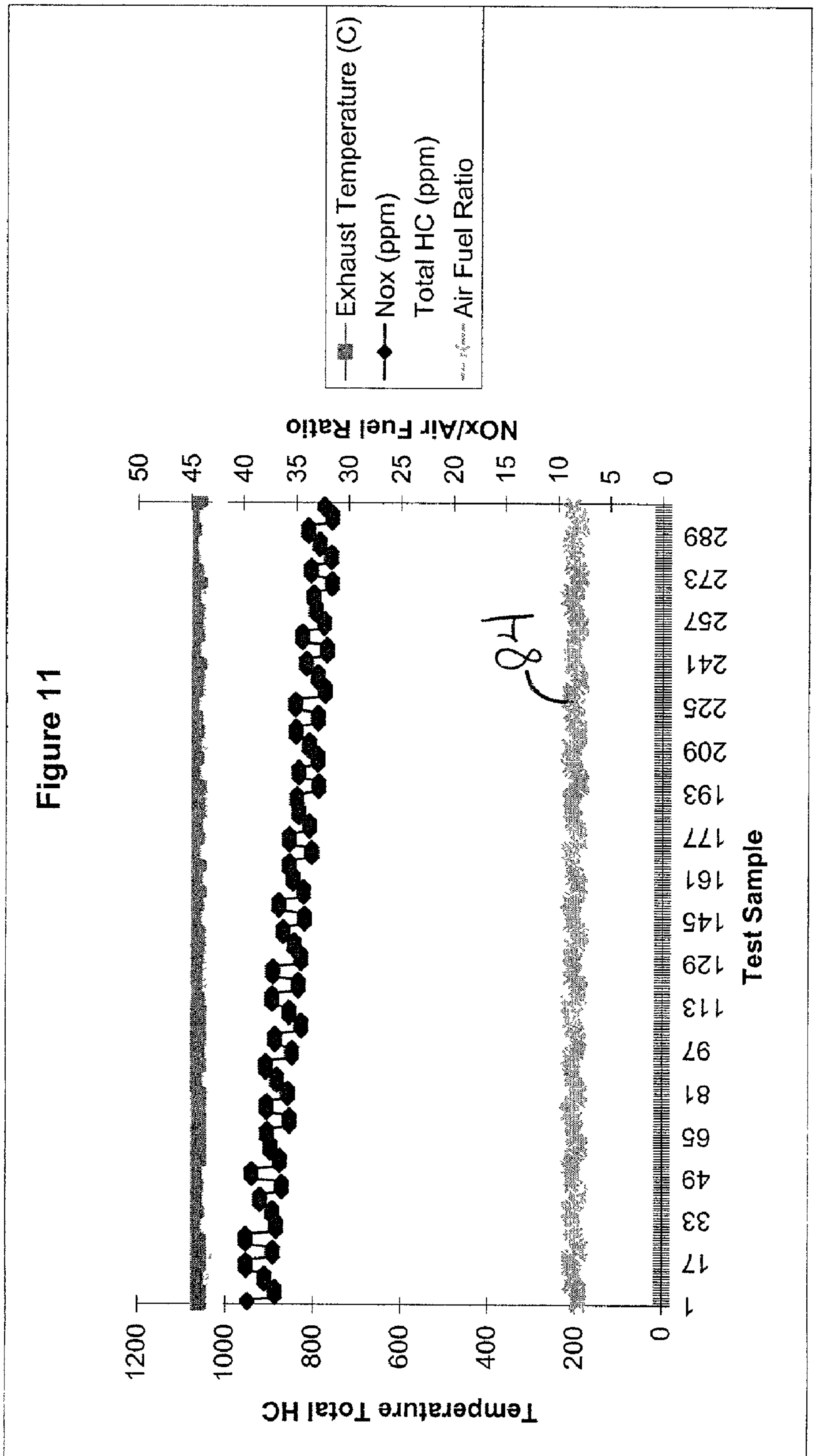
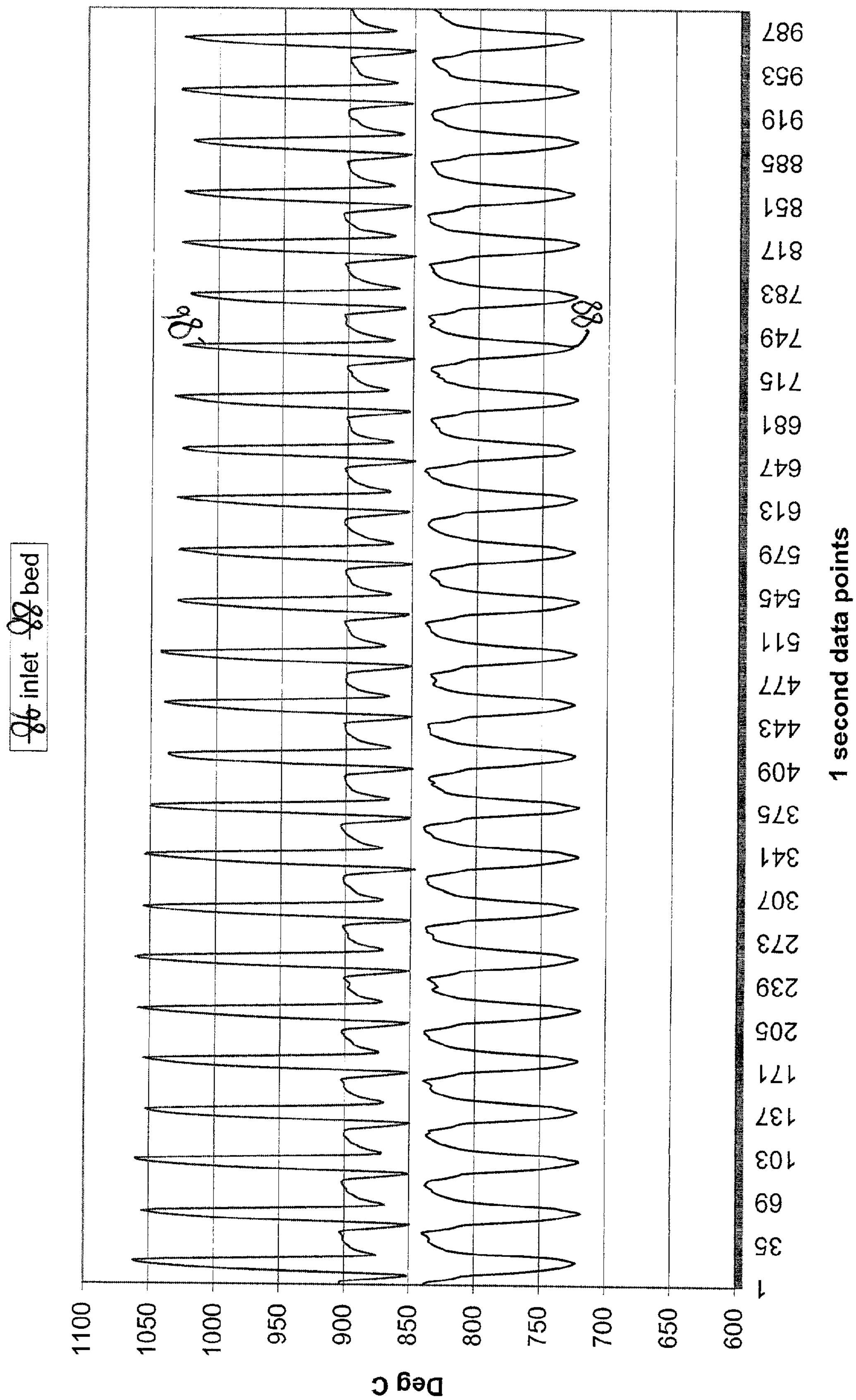

Exhaust Temperature (C)
Nox (ppm)
Total HC (ppm)
Air Fuel Ratio
Temperature Total HC
1200
1000
800
600
400
200
0
NOx/Air Fuel Ratio
50
45
40
35
30
25
20
15
10
5
0
Test Sample
1
17
33
49
65
81
97
113
129
145
161
177
193
209
225
241
257
273
289
78

Figure 11

Figure 12


96 inlet
98 bed
Deg C
1100
1050
1000
950
900
850
800
750
700
650
600
1 second data points
1
35
69
103
137
171
205
239
273
307
341
375
409
443
477
511
545
579
613
647
681
715
749
783
817
851
885
919
953
987
96
98

NON-ENGINE BASED EXHAUST COMPONENT RAPID AGING SYSTEM

CROSS REFERENCE TO RELATED APPLICATION

[0001] This application claims the benefit of the filing date of U.S. Provisional application Ser. No. 60/200852, filed May 1, 2000, which is incorporated herein in its entirety.

BACKGROUND OF THE INVENTION

[0002] Catalytic converter performance in an automobile will deteriorate over time due to such things engine misfire, a faulty oxygen sensor, poisoning, or prolonged high temperature operation. Deterioration of the catalytic converter in turn affects the catalyst's effectiveness for preventing the emission of undesired exhaust gases such as carbon monoxide (CO), nitrogen oxides (NO_x), and hydrocarbons (HC).

[0003] **FIG. 1** is a sectional view of a catalytic converter illustrating a catalyst-laden substrate wrapped in a support mat and inserted inside a shell. A catalytic converter **10** includes an inlet **30**, an outlet **50**, a shell **12**, a catalyst-laden substrate **14**, and a support mat **16** positioned between shell **12** and catalyst-laden substrate **14**. Each of the inlet port **30** and outlet port **50** is made a form of cone. Support mat **16** is preferably in intimate contact with either catalyst-laden substrate **14** or an inner surface **18** of shell **12**. Alternatively, support mat **16** is in intimate contact with both catalyst-laden substrate **14** and inner surface **18** of shell **12**.

[0004] Shell **12** may be of any geometric configuration that facilitates the intake of exhaust gas through the inlet port **30** that receives an inlet pipe extending from the internal combustion engine, allows the gas to flow through the shell **12** and contact the catalyst-laden substrate **14**, and flow out of the shell **12** through the outlet port **50**.

[0005] Support mat **16**, which is disposed between the catalyst-laden substrate **14** and the shell **12**, insulates the shell **12** from the catalyst-laden substrate **14** when the catalyst-laden substrate **14** reaches its operating temperature.

[0006] The composition of the catalyst is well known in the art and is typically disposed on the substrate **14** by a method well known in the art. Catalyst-laden substrate **14** is placed in the center of catalytic converter **10**. Common catalysts include nitrous oxide catalysts, three-way conversion (TWC) catalysts, or similar compositions that typically comprise noble metals, various metal oxides (e.g., titania, silica, alumina, ceria, tantala, zirconia, etc.) or mixtures and alloys thereof, as well as cordierite, vermiculite, and/or ceramic fiber.

[0007] The catalyst material comprises a multitude of passageways for reacting and converting byproduct exhaust gases. **FIG. 2** illustrate a catalyst substrate passage with exhaust gas interaction, prior to aging. In **FIG. 2**, reference numeral "**20**" represents a surface of one of these passageways. The catalyst substrate contains pores **22** within substrate layers to provide sufficient surface areas for exhaust gases from the engine to contact a catalyst **24**. When CO, NO_x, and HC contact the catalyst **24**, the molecules are substantially reacted with residual oxygen to produce carbon dioxide (CO_2) and nitrogen (N_2).

[0008] However as a catalytic converter ages with use, pores **22** begin to collapse thereby causing the catalytic converter to become less efficient in removing the undesired byproducts, i.e., CO, NO., and HC. In **FIG. 3**, some of the catalyst **24** is shown coalesced into larger particles. When the catalyst **24** coalesces and becomes larger due to aging, the amount of surface area available for catalytic reactions is reduced. Thereby, the efficiency in reducing the output of the byproducts is reduced. Modeling of the efficiency reduction in aging process helps developing exhaust treatment devices such as improved catalysts, catalytic converters, and/or oxygen sensors.

[0009] Further, a recent trend in legislation of automobile exhaust emissions is being focused on reducing emissions throughout the whole term of usage. To meet emission regulations, an automobile must have a catalytic converter which meets a certain requirement. That is, after 100,000 miles of running, the catalytic converter should maintain its performance of removing undesired emission gases in an optimum level which is required in a related regulation.

[0010] Therefore, it is useful to measure the degradation of a catalyst's performance as it ages. To gauge the aging performance, one method of practice has been to test catalysts by aging the catalysts using road testing with an automobile. However, this method of testing is both costly and time consuming.

[0011] An alternative method has been to modify an engine to artificially age the catalyst in order to avoid the necessity of road testing. As such, attempts have been made to alter the operation of the engine and artificially accelerate the aging process. The purpose of modifying the engine operating conditions is to assure that, after exposure to the accelerated aging, the catalyst reacts to emission gases in a similar manner as the catalysts which have been actually aged on a vehicle.

[0012] To simulate a field aged catalyst, prior methods include placing a catalyst on engine dynamometers and inducing various levels of misfire in order to degrade catalyst performance to the required threshold level. However, under steady state conditions, it is difficult to achieve the necessary temperatures to degrade or age the catalyst to a desired efficiency level within a reasonable time. Also, considerations about the availability of engine dynamometers and other resources required to meet the demand for threshold catalyst hardware with the misfire method may be limited.

[0013] As an alternative method, there has been an oven aging. Catalyst bricks are removed from the converter shell assembly and baked in an oven at temperatures ranging between 1,000 and 1,350° C. for 2-32 hours. After aging, the bricks are recanned and installed onto the vehicle. The vehicle is then usually driven for a few hundred miles to provide for a stabilization or break-in period prior to emission testing. However, it is difficult to determine the appropriate aging time and temperature required to degrade the catalyst performance to a specified level for a given vehicle.

SUMMARY OF THE INVENTION

[0014] A non-engine based exhaust component rapid aging system comprises a combustor in fluid communication with an air and a fuel supply; and a first emission analyzer in fluid communication with said combustor, wherein said first emission analyzer and said combustor are further capable of being disposed in fluid communication with an exhaust component; and wherein said non-engine based exhaust component rapid aging system is capable of operation at an air to fuel ratio of about 7 to about 16.

[0015] The non-engine based rapid aging method comprises combusting fuel with air to produce exhaust gas; controlling a temperature of said exhaust gas; supplying said exhaust gas to said exhaust component; and analyzing a composition of said exhaust gas.

[0016] The above-discussed and other features will be appreciated and understood by those skilled in the art from the following detailed description and drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0017] Referring now to the drawings, which are meant to be exemplary, not limiting:

[0018] **FIG. 1** is a sectional view of a catalytic converter;

[0019] **FIG. 2** is an illustration of a catalyst substrate passageway with exhaust gas interaction, prior to aging;

[0020] **FIG. 3** is an illustration of an aged catalyst substrate passageway with exhaust gas interaction;

[0021] **FIG. 4** is a schematic view of one embodiment of the rapid aging system;

[0022] **FIG. 5** is a schematic view of another embodiment of the rapid aging system;

[0023] **FIG. 6** is a perspective view of a stand including a combustor tube installed therein;

[0024] **FIG. 7** is a perspective view of a portion of the combustor as shown in **FIG. 6**;

[0025] **FIG. 8** is a graphical illustration of one example of the temperature control attainable with the non-engine based system.

[0026] **FIG. 9** is a graphical illustration of the temperature control attainable with the non-engine based system even at variable air to fuel ratios.

[0027] **FIG. 10** is a graphical illustration of stable exhaust temperature (e.g., the temperature control attainable) with the non-engine based system even at variable air to fuel ratios.

[0028] **FIG. 11** is a graphical illustration of an elevated temperature (1,060° C.) test for very rapid aging of a converter catalyst at a constant fuel flow of 0.4 grams/second (variation in the air to fuel ratio is due to the current method of air measurement).

[0029] **FIG. 12** is a graphical illustration of the lack of temperature control with the engine based system.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

[0030] The catalyst rapid aging system described herein can be used to age a catalyst converter, or other test specimen utilizing a feed stream of gases that are of a similar composition, temperature, and mass flow rate as those of a spark ignition engine such as an automobile engine.

[0031] Referring to **FIG. 4, a** schematic view of one embodiment of the rapid aging system, connected to a test converter **150** as a test device, is shown.

[0032] The rapid aging system comprises a combustor **120**, a heat exchanger **130**, and a first emission analyzer **160** connected to a line **135** between the heat exchanger and the test converter **150**. Like the line **135**, between components, a connecting line or tube is placed to ensure an operable communication through the system such that the exhaust gas produced in the combustor **120** is supplied to the test converter **150** for aging.

[0033] Following the heat exchanger, a laminar flow element **140** can be connected. The rapid aging system can further comprise an ignition element **122** and a blower **110** before the combustor. Also, the rapid aging system can further include a temperature sensor **162** following the heat exchanger **130**. A second emission analyzer **164** can be included after the test converter **150**.

[0034] The combustor **120** is supplied with air from a blower **110** and fuel **114** to produce exhaust gases. Also as shown, additional air **112** can be supplied to the combustor **120** if desired. An ignition source **122** provides the input of energy to allow combustion of the fuel and air in the combustor **120**. After the air/fuel mixture is combusted, the exhaust gases pass through the heat exchanger **130**. Passing throughout the heat exchanger **130**, the exhaust gas is cooled to a desired temperature. A coolant **132** is used to provide a desired exposure temperature to age the test converter **150**. If desired, a laminar flow element (LFE) **140** can be used to measure the flow of the exhaust gas is provided to the test converter **150** state. After passing through LFE **140** and prior to the exhaust gas entering the converter **150**, the exhaust gas temperature can be measured by the temperature sensor **162** for control of the system. Also, the first emission analyzer **160** can be used to measure the composition of the exhaust gas being admitted to the test converter **150**. As the emission analyzer, a gas sensor such as a wide range air/fuel sensor can be employed. After passing through the test converter **150**, the second emission analyzer **164** can be used to measure the composition of the exhaust gas. Similarly, a wide range air/fuel sensor can be used for the second emission analyzer **164**.

[0035] By using one or more emission analyzers, the system can be controlled so as to accurately provide exhaust gases to age the test converter **150**. By providing an accurate exhaust gas flow to the test converter **150**, an accurate aging analysis of the test converter **150** can be achieved. Alternatively, other devices requiring aging can be aged and tested in place of or along with the test converter **150**. For example, an oxygen sensor can be aged using this system.

[0036] In **FIG. 5**, another embodiment of the rapid aging system is shown. While only one connecting line is represented as reference numeral "**235**" in **FIG. 5, a** connecting line or tube through which the exhaust gas flows is placed between components. A combustor **220** is fed with supplies of air (A) and fuel (F). After the fuel is combusted in combustor **220**, the exhaust gas is optionally fed to a turbocharger **222** wherein the pressure and amount of exhaust gas finally supplied to a test converter **250** can be adjusted. Additional air can be provided to the turbocharger **222** or a portion of the exhaust gas can be vented from the turbocharger **222**. After the turbocharger **222**, the temperature of the exhaust gas is measured by a temperature sensor **268** for control of the system and particularly for control of a heat exchanger **230**. Also at this stage, a second emission analyzer **264** can be used to determine the exhaust gas composition for control of the system, particularly for the input of air and fuel into the combustor **220**.

[**0037**] Thereafter, the exhaust gas flow is directed through the heat exchanger **230**. As shown, the heat exchanger **230** is fed with a coolant. By thermal exchange between the coolant and the exhaust gas, the exhaust gas is brought to a desired temperature for exposure to the converter **250** for aging. Optionally, a temperature sensor **262** can be used to measure the temperature of the exhaust gas for control of the system. A first emission analyzer **260** samples the exhaust gas prior to the test converter **250**, for system control, particularly for the input of air and fuel into the combustor **220**. Also, additional exhaust gas or contaminant can be added to the exhaust gas flow by a contaminant supplier **266**. As the contaminant, any contaminants commonly found in exhaust gases can be used, for example, zinc dialkyldithiophosphate (ZDP) which serves as a lubricating additive for corrosion resistance, wear resistance, and antioxidation.

[**0038**] After treatment by the rapid aging system, the exhaust gas is fed to the test converter **250** for aging thereof. Optionally, an additional emission analyzer (not shown) can measure the exhaust gas composition after passing through the test converter **250** for system control. Alternatively, other devices, such as oxygen sensors requiring aging can be aged and tested in place of or along with the test converter **250**.

[**0039**] **FIG. 6** is a perspective view illustrating one embodiment of the combustor mounted on a stand. In **FIG. 6**, reference numeral **300** represents a stand, and reference numeral **320** represents a combustor. The combustor is not limited to a specific structure. The combustor can be made in a simple tubular form as shown in **FIG. 6**. The non-engine based rapid aging system is highly portable and can be made in a small size. Also, the system is very safe because it is not based on an internal combustion engine with rotating shafts. Simplified structure enables the system to be easily controlled, thus, aging variability can be minimized and aging process can be expedited.

[**0040**] **FIG. 7** is a perspective view of a portion of the combustor as shown in **FIG. 6**, and illustrates one embodiment of connecting several suppliers such as blower inlet, fuel inlet, injector power cord, and spark ignition to the combustor **320**.

[**0041**] Using the system as shown in **FIG. 4**, rapid aging tests were performed. The test results are graphically illustrated in FIGS. **8-11**. In **FIG. 8**, the non-engine based system illustrated good temperature control, e.g., a temperature variation of about 20° C. or less, with about 110° C. or less preferred, about 5° C. or less more preferred, and a temperature variation of about 2° C. or less especially preferred. In contrast, an engine based test system illustrated a temperature variation of about 40° C., with temperature variations of about 100° C. or greater common. (See **FIG. 12**). In engine based test systems, and/or to the temperature varies due to the speed or torque control of the dynamometer, to the addition of fuel to maintain a stoichiometric air to fuel ratio. Basically, the engine based test system does not control temperature; the temperature is a function of the system and not controlled. A problem with lack of temperature control is the destruction of the test part, e.g., a catalytic converter, due to melting of the brick under extreme conditions. By controlling the temperature, the non-engine based system is capable of eliminating the failure mode associated with destruction of the test part by excessive heat, and of accelerating aging.

[**0042**] **FIGS. 9 and 10** further illustrate the ability of the non-engine based rapid aging system to maintain exhaust gas temperature (lines **62** and **72**, respectively), while varying the input fuel, evidenced by the air fuel ratio (lines **60** and **70**, respectively).

[**0043**] Finally, **FIG. 11** illustrates an elevated temperature test (i.e., 1,060° C.) for very rapid aging of a converter catalyst. Beyond further illustrating the ability to maintain the temperature, the graph proves that the non-engine based system can be operated at extreme air to fuel ratios. Engine based aging systems can only operate near stoichiometry. This non-engine based system can operate at rich, namely at an air to fuel ratio of about **10** or less, with about 7 or less, and even about 2 or less possible. (See line **84**) On the lean side, the air to fuel ratio can reach and exceed about 16, with a ratio of about 17 and greater also possible.

[**0044**] As described above, the rapid aging system is non-engine based system. By using the non-engine based rapid aging system, the efficiency of a catalytic converter can be projected throughout its lifetime more accurately and consistently as compared with an engine-based system.

[**0045**] The non-engine based exhaust component rapid aging system provides advantages of simplifying a catalytic converter test (or other exhaust component) and a testing hardware. This is achieved by eliminating the need for spark ignition engine, e.g., automobile engine, which thereby reduces the costs associated with converter aging and testing. Another advantage is the reduction of testing variability due to the improved controllability of the exhaust gas composition. Pressure, mass flow and temperature of the exhaust gas can be controlled as well. The reduction in testing variability provides better data for design of products such as catalytic converters, oxygen sensors, particulate traps, and the like.

[**0046**] This system allows for a lean air to fuel testing arrangement, which thereby allows for rapid changes between different products for testing and aging. This is achieved by changing the system control program and test sample. Further, unlike engine based aging systems which operate around stoichiometric air to fuel ratios (12 to about 16.7), this non-engine based system is capable of operating at an air to fuel ratio of about 10 or less, with about 7 or less and even about 2 or less possible. Air to fuel ratios exceeding about 15.5 are similarly possible, with ratios of about 17 and even about 18 or greater possible.

[**0047**] Since the combustor of the rapid aging system can produce temperatures similar to an engine, performance testing and aging can be accomplished. Further, when the optional heat exchanger is employed, aging time can be diminished and better controlled than with an engine based test rig. In addition to temperature control, the system enables contaminant control by allowing the introduction of, or increased concentration of contaminants, e.g., sulfur, nitrogen oxides, and the like, prior to the exhaust component.

[0048] The non-engine based rapid aging system is highly portable and can be made in a small unit. Also, the system is very safe compared with engine-based systems. It is very simple to control the system, thus, aging variability can be minimized and aging process can be expedited.

[0049] While the invention has been described with reference to an exemplary embodiment, it will be understood by those skilled in the art that various changes may be made and equivalents may be substituted for elements thereof without departing from the scope of the invention. In addition, many modifications may be made to adapt a particular situation or material to the teachings of the invention without departing from the essential scope thereof. Therefore, it is intended that the invention not be limited to the particular embodiment disclosed as the best mode contemplated for carrying out this invention, but that the invention will include all embodiments falling within the scope of the appended claims.

1. A non-engine based exhaust component rapid aging system, comprising:

a combustor in fluid communication with an air and a fuel supplier; and

a first emission analyzer in fluid communication with said combustor, wherein said first emission analyzer and said combustor are further capable of being disposed in fluid communication with an exhaust component, and wherein said non-engine based exhaust component rapid aging system is capable of operation at an air to fuel ratio of about 10 to about 17.

2. The rapid aging system as claimed in claim 1, further comprising a heat exchanger in fluid communication with said combustor and said exhaust system component.

3. The rapid aging system as claimed in claim 1, further comprising a laminar flow element in operable communication with said other end of the heat exchanger.

4. The rapid aging system as claimed in claim 1, further comprising an ignition element in operable communication with said combustor.

5. The rapid aging system as claimed in claim 1, further comprising a blower in fluid communication with said combustor.

6. The rapid aging system as claimed in claim 1, further comprising a temperature sensor in operable communication with said exhaust gas passage line.

7. The rapid aging system as claimed in claim 1, further comprising a second emission analyzer disposed between said combustor and said heat exchanger.

8. The rapid aging system as claimed in claim 1, further comprising an exhaust gas conduit in fluid communication said heat exchanger and a contaminant supply.

9. The rapid aging system as claimed in claim 8, wherein said contaminant supply comprises sulfur.

10. The rapid aging system as claimed in claim 1, further comprising a turbocharger disposed in fluid communication with said combustor and said heat exchanger.

11. The rapid aging system as claimed in claim 1, wherein said exhaust component is a catalytic converter.

12. The rapid aging system as claimed in claim 1, wherein said exhaust component is an oxygen sensor.

13. The rapid aging system as claimed in claim 1, wherein said air to fuel ratio is about 2 to about 17.

14. A non-engine based exhaust component rapid aging system comprising:

a combustor in fluid communication with an air and a fuel supplier;

a turbocharger disposed in fluid communication with said combustor;

a heat exchanger in fluid communication with said turbocharger;

a first emissions analyzer in fluid communication with said combustor and said heat exchanger; and

a second emission analyzer in fluid communication with said heat exchanger, wherein said first emission analyzer and said heat exchanger are further capable of being disposed in fluid communication with a test component.

15. A non-engine based method of rapid aging an exhaust component comprising:

combusting fuel with air to produce exhaust gas;

controlling a temperature of said exhaust gas;

supplying said exhaust gas to said exhaust component; and

analyzing a composition of said exhaust gas.

16. The method as claimed in claim 15, further comprising controlling a pressure and an amount of the exhaust gas prior to said adjusting the temperature of said exhaust gas.

17. The method as claimed in claim 15, further comprising supplying a contaminant to said exhaust gas prior to supplying said exhaust gas to said exhaust component.

18. The method as claimed in claim 15, wherein said contaminant comprises sulfur.

19. The method as claimed in claim 15, wherein said exhaust component is a catalytic converter.

20. The method as claimed in claim 15, wherein said exhaust component is an oxygen sensor.

21. The method as claimed in claim 15, further comprising an air to fuel ratio supplied to said combustor.

22. The method as claimed in claim 15, wherein said fuel and said air have an air to fuel ratio of about 10 or less.

23. The method as claimed in claim 22, wherein said air to fuel ratio is about 7 or less.

24. The method as claimed in claim 23, wherein said and an air to fuel ratio is about 2 to about 7.

25. The method as claimed in claim 15, wherein said and an air to fuel ratio is about 16 or more.

26. The method as claimed in claim 15, wherein said and an air to fuel ratio is about 17 or more.

27. A non-engine based rapid aging system comprising:

means for combusting fuel with air to produce exhaust gas;

means for controlling a temperature of said exhaust gas;

means for supplying said exhaust gas to said exhaust component; and

means for analyzing a composition of said exhaust gas.

* * * * *