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(54) Titre : SYSTEME CATALYTIQUE PERMETTANT DE CONVERTIR LES COMBUSTIBLES LIQUIDES EN GAZ DE SYNTHESE
(54) Title: CATALYTIC SYSTEM FOR CONVERTING LIQUID FUELS INTO SYNGAS

(57) Abrégé/Abstract:

The present invention is a method and a system for the gasification of a liquid fuel and includes providing a supply of a liquid fuel and an oxidant, atomizing the liquid fuel and mixing it with the oxidant, catalytically reacting the fuel oxidant mixture, providing an ignition source for initiating the catalytic reaction, positioning a heat exchanger in proximity with the catalytic bed, and producing steam which can be fed back into the system thereby eliminating the need for a vaporizer. A hydrocarbon fuel can be mixed with oxygen, as a constituent of air, preferably forming a fuel rich fuel air mixture that passes through a catalytic reactor having an ultra-short channel length metal monolith substrate.

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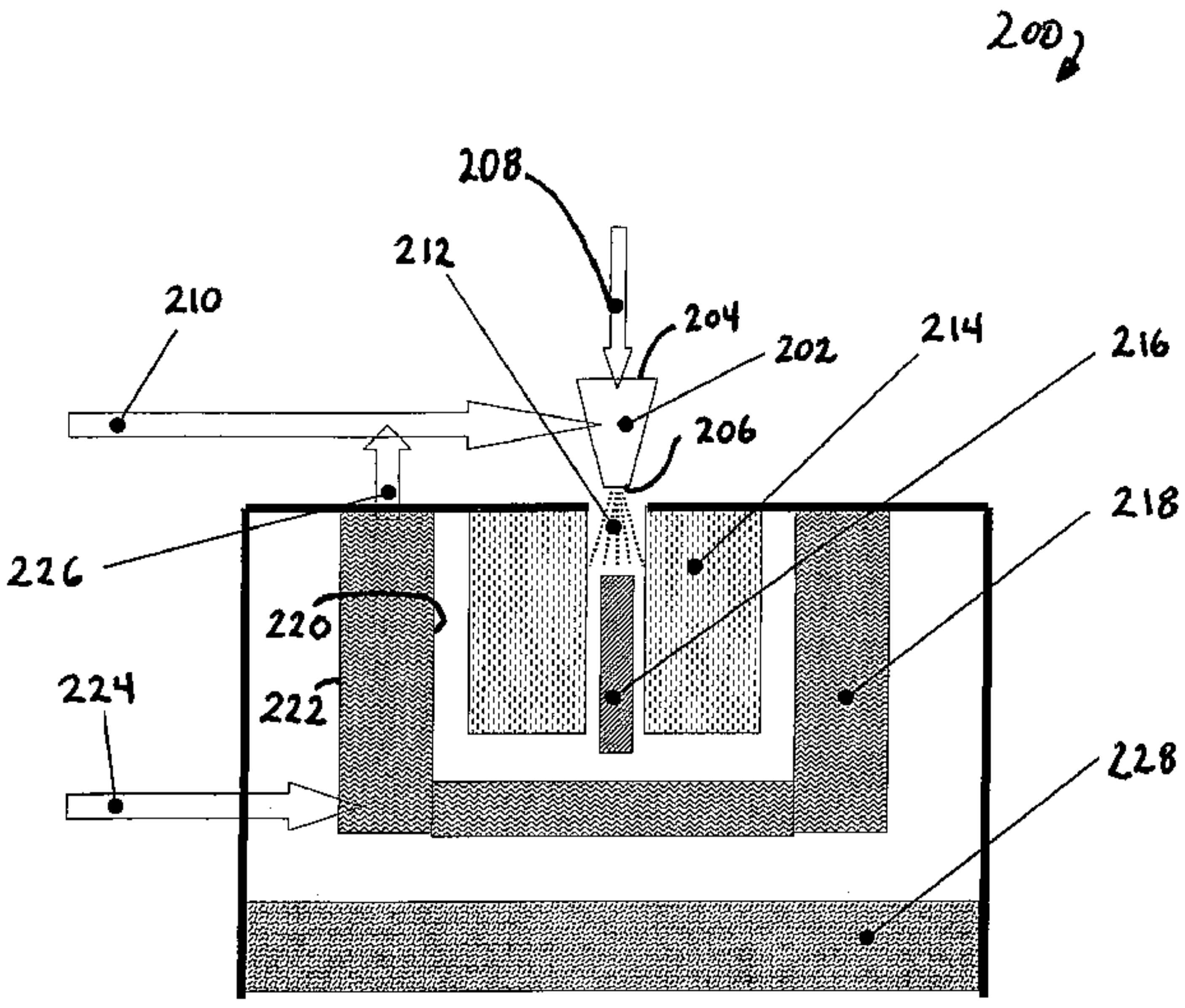

FIG. 3

(57) Abstract: The present invention is a method and a system for the gasification of a liquid fuel and includes providing a supply of a liquid fuel and an oxidant, atomizing the liquid fuel and mixing it with the oxidant, catalytically reacting the fuel oxidant mixture, providing an ignition source for initiating the catalytic reaction, positioning a heat exchanger in proximity with the catalytic bed, and producing steam which can be fed back into the system thereby eliminating the need for a vaporizer. A hydrocarbon fuel can be mixed with oxygen, as a constituent of air, preferably forming a fuel rich fuel air mixture that passes through a catalytic reactor having an ultra-short channel length metal monolith substrate.

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CATALYTIC SYSTEM FOR CONVERTING LIQUID FUELS INTO SYNGAS

BACKGROUND OF THE INVENTION

Field of the Invention

[0002] The present invention is directed to a method and system for the process of reactively converting a liquid fuel into a gasified stream. More particularly, the method and system of the present invention provide a novel means for converting the liquid fuel into a gas by partial oxidation and steam reforming. In addition, when fuels containing sulfur are used, a device according the present invention can be employed to provide de-sulfurization.

Brief Description of the Related Art

[0003] Gasification of liquid fuels typically comprises use of a vaporizer. Vaporization of liquid fuels (e.g., alcohols, hydrocarbons) typically is achieved by indirectly supplying heat into a stream of liquid fuel via heat exchange with a hot wall. One disadvantage of this method is that the rate of vaporization is limited by the rate of heat transfer such that relatively large surface area is required for fuel vaporization. Another disadvantage of this method, especially for vaporizing long chain hydrocarbons, is that heating the fuel stream to the vaporization temperature tends to cause fuel decomposition and formation of deposits.

More specifically, coke formation is problematic. Moreover, preventing deposits from forming within the fuel passages in the nozzle during steady state operation due to heat-up of the nozzle from the downstream hot zone is challenging.

[0004] Another known method for gasification of a fuel stream comprises mixing atomized fuel with a hot gas such as superheated steam that supplies the heat required for fuel vaporization and prevents coke formation. However, the large amounts of superheated steam required in this method result in a large heat load for steam production.

[0005] Spray methods for atomization of liquid fuels known in the art include air-blast or pressure atomizers, ultrasonic and electrospray atomizers. These spray systems are capable of providing a uniform distribution of atomized fuel across the entrance of the catalyst bed. Such atomizers may include a co-flow of air that allows mixing of the fuel and oxidizer. However, very fine and uniform droplet size along with homogeneous fuel-air distribution, required to avoid coke formation and obtain temperature/mixture uniformity in the reactor, is difficult to achieve in practical systems.

[0006] Ignition devices, such as a spark or glow plugs, are widely used to ignite fuel-oxidizer mixtures at startup. These devices often are subject to failure due to the high operating temperatures by virtue of their location required for ignition.

[0007] Monoliths are commonly used catalyst substrates for the gasification of liquid fuel. Fuel oxidizer mixture inhomogeneities are usually detrimental to these substrates as they lead to localized lean or rich zones respectively causing hot spots or carbon precipitation regions. Since there is no opportunity for these zones to re-mix within the long, separated channels of a monolith, these substrates are particularly vulnerable. In addition, carbon precipitation is favored in monoliths due to the boundary layers that develop in these substrates.

[0008] Combustion of liquid fuels in fuel cell or internal combustion engine systems poses significant problems, especially for fuels with high aromatic content and wide boiling point distribution. This can be attributed to the propensity of the heavier aromatic compounds in the fuel to form deposits or coke when vaporized at high temperatures.

[0009] Liquid hydrocarbon fuels such as gasoline, kerosene or diesel may be used with high temperature solid oxide fuel cells ("SOFC") to directly produce electric power. For these fuel cells, the choice of fuel is not limited to pure hydrogen as is the case for low temperature proton exchange membrane ("PEM") fuel cells. Conversion of the hydrocarbon fuel into gaseous mixture containing syngas, though, is required before the fuel may be fed to the SOFC. Furthermore, removal of sulfur normally contained in the fuel prior to feeding to the SOFC is needed.

[0010] These and other known methods and systems for gasification of liquid fuels, together with their associated disadvantages, are described further in U.S. 2005/0028445.

[0011] Gasification and pre-reforming of liquid fuel would resolve many of the issues noted above with respect to the prior art. Accordingly, there is a need for a pre-reforming reactor capable of operating with a range of liquid fuels. It is therefore an object of the present invention to provide a pre-reforming reactor for partially oxidizing and cracking the heavy components of the fuel. The pre-reformed fuel subsequently can be further reformed or combusted to power fuel cell systems, internal combustion engines, burners, and other known devices.

[0012] It is therefore another object of the current invention to provide a catalyst substrate that facilitates mixing of the stream flowing therethrough, for example a substrate having plurality of voids in random order and short channels extending in the downstream direction the length of which is similar to the channel diameter. Such a configuration results in a comparatively high conversion rate of the reactants to the desired products and minimizes break through of unreacted fuel.

[0013] It also is an object of the current invention to provide a catalytic reactor for the gasification of liquid fuels comprising a catalyst that yields partial oxidation products, such as CO and H_2. This results in a higher level of fuel conversion for the same amount of added air and produces hydrogen-rich gas directly from the gasifier reactor. It is a further object of the current invention to provide a method whereby steam or atomized water and/or CO_2 may be added to the fuel/air stream to adjust the amount of hydrogen in the product stream. It also is a further object of the current invention to provide a method whereby no external pre-heating of either air or fuel is required.

[0014] Lastly, it is a further object of the present invention to provide de-sulfurization of the fuel in the liquid form when required by a particular application of the gasification system taught herein.

DESCRIPTION OF THE INVENTION

[0015] The system of the present invention eliminates the need for a liquid fuel vaporizer in a typical gasification system. By eliminating the vaporizer, an essential and critical part of the reforming systems known in the art, the entire system is less complex and more robust. Vaporizing hydrocarbon fuels is difficult because of low decomposition temperature of these fuels which leads to coke deposits and clogging of the fuel delivery lines. Spraying cold fuel directly into the catalyst bed eliminates this problem.

[0016] In one embodiment of this invention, a heat exchanger is positioned downstream of the catalyst bed thereby utilizing the heat generated in the reforming reaction to produce steam required for the system while cooling the reformate stream to the temperature required by the downstream components, i.e. de-sulfurization bed.

[0017] In yet another embodiment of this invention, a de-sulfurization bed is positioned downstream of the catalyst bed. In other systems known in the art, de-sulfurization is achieved by de-sulfurization of the fuel in the liquid form in a hydro-de-sulfurization ("HDS") process prior to the reforming process.

[0018] In summary, the present invention is a system for converting liquid fuels into gas mixture containing CO and H2 (syngas). The system is comprised of: (i) a nozzle; (ii) a catalyst bed in fluid communication with the nozzle exhaust stream; (iii) a heat source for igniting the catalyst; and (iv) a heat exchanger. The hot side of the heat exchange is in fluid communication with the catalyst bed and the cold side of the heat exchanger in fluid communication with the nozzle.

[0019] Atomized liquid fuel is exits the nozzle in a stream comprising an oxidizer and optional steam. In most applications, oxygen as a constituent of air is a preferred oxidizer. The ratio of the fuel stream to the oxidizer stream should be such that there is insufficient amount of oxidizer to completely oxidize all fuel into CO2 and H2O, i.e. the ratio should be fuel rich.

[0020] The fuel entering the nozzle is cold (i.e., below the temperature at which the fuel starts to decompose creating coke deposits). The nozzle design is such that the liquid fuel remains cold before exiting the nozzle. This is an important point distinguishing this invention from previous methods, for example US Patent No. 4,381,187.

[0021] The nozzle may be of any type (i.e., based on pressure atomization, air blast, ultrasonic atomization, electrospray, or other type known in the art). The nozzle provides fine atomization of cold liquid fuel and uniform distribution of the atomized fuel within the inlet air or optionally steam containing inlet air. Appropriate nozzles in which reaction air and/or steam flow and/or fuel flow are used to atomize liquid fuel.

[0022] The catalyst bed comprises catalyst suitable for supporting partial oxidation and reforming reactions. Preferably the catalyst is one of the metals of group VIII of the periodic system of elements, preferably, rhodium. The substrate on which the catalyst is supported preferably provides good mixing for the fuel/oxidizer mixture passing therethrough. To provide good mixing capabilities, the substrate preferably comprises a multiplicity of void volumes in random order. This may be best achieved by using porous metal or ceramic substrates or by using multiple ceramic or metal screens or foams.

[0023] The preferred catalyst bed geometry provides a decreasing mass flux of the reactive mixture flow through the catalyst bed as disclosed in WO 2004/060546.

As an example of such geometry is a coil of Microlith™ short-contact-time, ultra-short-channel-length substrate and catalyst where the reactive mixture is introduced in the ID plenum and the reformed gas exits at the OD of the coil. Preferred catalyst formulations could be used on different parts of the coil. Microlith™ short-contact-time, ultra-short-channel-length substrate is available from Precision Combustion, Inc., 410 Sackett Point Road, North Haven, Connecticut.

[0024] The nozzle and the catalyst bed are arranged in such a way that the stream of atomized fuel mixed with air and steam provided by the nozzle is uniformly distributed across the entry face of the catalyst bed. It is preferred that the rate of flow of the reacting mixture through the catalyst bed is sufficiently high such that significant amounts of partial oxidation products (i.e., CO and H2) are formed. When partial oxidation products are formed, less heat is released thereby resulting in lower temperatures of the catalyst bed.

[0025] The heat/ignition source is placed in closed proximity with the catalyst bed. It is required for the initial pre-heat of the catalyst to the temperature where the oxidation reaction between the fuel and the oxidant would ignite. The heat source may be of any type known in the art. An electrically heated glow plug is a preferred heat source.

[0026] The heat exchanger downstream of the catalyst bed can be any type of a heat exchanger known in the art. The heat exchanger should be placed such that the gaseous reformate flow exiting the catalyst bed passes on the hot side the heat exchanger. The heat exchanger then cools the reformate flow to the required temperature. The heat exchanger vaporizes cold liquid water to produce steam which is fed to the nozzle outlet.

[0027] In some embodiments of the invention, a sulfur removal bed may be placed in fluid communication with the heat exchanger. In this embodiments, the cooled reformate stream containing sulfur in the form of H_2S exiting the heat exchanger passes through the sulfur removal bed to provide a sulfur free reformate stream.

[0028] The method and system of the present invention provide gasification of liquid fuel without a requirement for supplying external heat or steam to the gasifier. Fuel and air may be supplied to the gasifier at ambient temperatures. This allows a smaller mixing volume, since the catalytic bed tolerates partial unmixedness, and a simpler fuel and air delivery system design. This also allows a means for start up and operation in the absence of initial heat at the reactor inlet. More importantly, the method and system of the present invention provide a means for the gasification of a liquid fuel without the use of an external vaporizer.

[0028a] In accordance with an aspect of the present invention, there is provided a process for gasification of a liquid fuel comprising: (a) providing a supply of the liquid fuel; (b) providing a supply of an oxidant; (c) providing a supply of liquid water; (d) atomizing the liquid fuel through a nozzle into a mixer such that the fuel entering the nozzle and before exiting the nozzle is maintained at a temperature below the coking temperature of the fuel; (e) feeding the oxidant into the mixer and mixing the atomized fuel with the oxidant; (f) catalytically reacting the fuel-oxidant mixture in the presence of steam in a catalytic reactor thereby producing gaseous reformate; wherein the catalytic reactor comprises a substrate in a coiled configuration having an inner diameter and an outer diameter and a radial flow path, and having supported thereon one or more Group VIII metals; (g) initiating the catalytic reaction of step (f) with an ignition source positioned inside the inner diameter of the coiled substrate; (h) contacting the gaseous reformate with a heat exchanger positioned downstream of and in fluid communication with the catalytic reactor, such that a hot side of the heat exchanger contacts the gaseous reformate and a cold side of the heat exchanger contacts the supply of water; and further such that the heat exchanger is displaced radially with respect to a center axis of the catalytic reactor and wherein the gaseous reformate exits through the radial flow path of the catalytic reactor and contacts the heat exchanger in a crossflow direction; (i) transferring heat from the gaseous reformate via the heat exchanger to the liquid water to produce steam; and (j) providing the steam to the fuel-oxidant mixture in the catalytic reaction of step (f).

[0028b] In accordance with a further aspect of the present invention, there is provided a system for converting a liquid fuel into a gasified stream, the system comprising: (a) a nozzle having an outlet for feeding a fuel and an oxidant into contact with a reforming catalyst; (b) a fuel inlet for feeding the fuel into the nozzle; (c) an oxidant inlet for feeding the oxidant into the nozzle; (d) the reforming catalyst positioned downstream from the outlet of the nozzle, the catalyst being supported on a substrate comprising a metal screen in a coiled configuration having an inner diameter and an outer diameter and a radial flow path; (e) an ignition source located inside the inner diameter of the metal screen for igniting the catalyst; (f) a heat exchanger placed within the system downstream of the catalyst such that a hot side of the heat exchanger is in fluid communication with the catalyst and a cold side of the heat exchanger is in fluid communication with a supply of water so as to produce steam; and further such that the heat exchanger is displaced radially with respect to a center axis of the coiled metal screen and the heat exchanger has a flow path positioned in crossflow direction with respect to the radial flow path of the coiled metal screen; (g) a means for feeding steam into contact with the catalyst.

Brief Description of the Drawings

[0029] Fig. 1 depicts a schematic representation of an embodiment of a gasification system.

[0030] Fig. 2 depicts a schematic representation of another embodiment of a gasification system according.

[0031] Fig. 3 depicts a diagrammatic representation of a detailed design of a gasification system according to the present invention.

[0032] Fig. 4a and 4b provide a three-dimensional rendering of a detailed design of a gasification system according to the present invention.

[0033] Fig. 5 provides a graphical representation of lightoff temperature versus time in a gasification system according to the present invention.

[0034] Fig. 6 provides a graphical representation of the dependence of fuel conversion on the air-to-fuel ratio in a gasification system according to the present invention.

[0035] Fig. 7 provides a schematic flow diagram of a gasification system according to the present invention.

Detailed Description of the Invention

[0036] As depicted schematically in Fig. 1, a typical gasification system (10) comprises a path (12) defining a flow of air (14). Fuel stream (16) is introduced into injector (18), which atomizes fuel stream (16). Atomized fuel (20) and air (14) enter catalyst bed (22) where fuel (20) is additionally mixed, vaporized and partially reformed. Gasified fuel stream (24) leaves the catalyst bed (22). Ignition source (26), in close proximity with catalyst bed (22), is used to initiate the process.

[0037] Fig. 2 schematically depicts alternative gasification system (110). Functional elements corresponding to those depicted in Fig. 1 are referenced by corresponding 100-series reference numbers. In this embodiment, catalyst bed (122) defines a cylindrical shape and comprises a wound catalytically coated, short-contact-time, ultra-short-channel-length substrate. Atomized fuel (120) and airflow (114) enter into the inner diameter (128) of catalyst bed (122) and flow out radially (130) through catalyst bed (122). The igniter (126) in this embodiment comprises an electric glow plug (132) placed inside inner diameter (128) of catalyst bed (122). Glow plug (132) may be coated with catalyst (134) to further assist the start up process. Electric current initially is supplied to glow plug (132) to preheat catalyst bed (122) to the start up temperature. Fuel stream (116) is introduced into injector (118), and air (114) is then mixed with atomized fuel (120) causing catalyst bed (122) to heat up to the operating temperature at which point the electric current to the glow plug (132) is stopped. Gasified fuel stream (124) exits the system (110).

[0038] Fig. 3 depicts a diagrammatic representation of a design of a gasification system (200) according to the present invention for converting liquid fuels into gas mixture containing CO and H2 (syngas). The system (200) is comprised of a nozzle (202) having an inlet (204) and an outlet (206). A cold fuel liquid stream (208) and an inlet oxidizer stream (210) are introduced into the inlet (204) (which inlet may have more than one orifice). A nozzle exhaust stream (212) comprising atomized liquid fuel mixed with oxidizer and, if desired, steam exits nozzle (202) at outlet (206). Catalyst bed (214) is in fluid communication with the nozzle exhaust stream (212). The system (200) further comprises a heat source (216) for igniting the catalyst bed (214). A heat exchanger (218) is in fluid communication with, or placed in close proximity with, the catalyst bed (214) and the nozzle (202).

[0039] Atomized liquid fuel exits the nozzle (202) in exhaust stream (212) which further comprises an oxidizer and optional steam. In most applications, oxygen as a constituent of air is a preferred oxidizer. The ratio of the fuel stream to the oxidizer stream should be such that there is insufficient amount of oxidizer to completely oxidize all fuel into CO_2 and H_2O, (i.e., the ratio should be fuel rich).

[0040] Exhaust stream (212) is uniformly distributed across the entry face of the catalyst bed (214). Preferably, the reactive mixture comprising exhaust stream (212) is introduced in the ID plenum of the catalyst bed (214) and the reformed gas exits at the OD of the catalyst bed (214) coil.

[0041] The heat/ignition source (216) is placed in closed proximity with the catalyst bed (214) in order to pre-heat the catalyst bed (214) to the temperature where the oxidation reaction between the fuel and the oxidant ignite. Gaseous reformate flow exits the catalyst bed (214) in fluid communication with a first side (220) of heat exchanger (218). The gaseous reformate is then cooled to the required temperature by passing through, or in close proximity with, heat exchanger (218). The second side (222) of heat exchanger (218) vaporizes cold liquid water stream (224) to produce steam (226), which is fed to the inlet (204) of nozzle (202).

[0042] If desired, a sulfur removal bed (228) may be placed in fluid communication with the first side (220) of heat exchanger (218). In this embodiment, the cooled reformate stream containing sulfur in the form of H_2S exiting the heat exchanger (218) passes through the sulfur removal bed (228) to provide a sulfur free reformate stream.

[0043] Fig. 4a and 4b provide a three-dimensional rendering of detailed design of a gasification system (300) according to the present invention. An Auto Thermal Reforming (ATR) reactor comprised a coiled catalyst bed, a fuel atomization nozzle and a start up glow plug. The reactor comprises the core of the reforming system, which system is further incorporated into a system comprising a heat exchanger/steam generator, ZnO de-sulfurization bed and fuel, air and water pump. The ATR was enclosed in a quartz housing to enable visual observation of the catalyst temperature uniformity. The reactor was also equipped with eight thermocouples for studying temperature distribution within the catalyst bed. Gasification system (300) is an embodiment of gasification system (200) described hereinabove and some of the features are called out using similar characteristics numbers for descriptive and illustrative purposes.

[0044] Fig. 4a depicts the system (300), catalyst bed (314), heat/ignition source (316), and heat exchanger (318). Fig. 4a also depicts, among other features described hereinabove with reference to Fig. 3, cold fuel liquid stream inlet (308), oxidizer stream inlet (310), and liquid water stream inlet (324).

[0045] The glow plug permits the reactor to lightoff at ambient conditions. In order to start the reactor, 12 V DC potential is applied to the glow plug providing heat directly to the catalyst. This results in catalyst temperature increasing to above lightoff temperature in about 30 seconds. Fuel flow is then started resulting in the reactor lightoff and transition to operational state in about 1 minute. As the catalyst lights off, the glow plug is shut off and steam flow to the reactor is started. This causes temperature decrease on the front of the catalyst bed, such that more air can be added to the reactor and complete fuel conversion achieved. Reactor temperatures during the lightoff process are shown in Figure 5.

[0046] The reformate gas was analyzed by a GC at each O:C setting to measure the gas composition and the reactor performance. The inlet temperature and the S:C ratio were then varied and the O:C scan repeated to measure the dependence of the ATR performance on inlet temperature, air-to-fuel ratio (O:C) and steam-to-fuel ratio (S:C). The results are provided in Figure 6. It was found that the reactor could be operated with low water addition (S:C ~ 1). It was also found that increasing the inlet temperature improved reactor performance. At 400°C and S:C = 1.1, the JP-8 reforming efficiency (LHV based) was ~65%. Note that due to equipment tolerances analytical considerations resulted in a maximum 95% material balance. The flattening of the conversion curve indicates that this corresponds in actuality to essentially complete fuel conversion.

[0047] ASPEN® modeling was used to examine and determine the system layout including sensitivities to water addition/recycle/recapture and their associated impacts. The system configuration is illustrated in Figure 7. The system operates at approximately 1 – 2 atm. The ATR feed water is delivered to a heat exchanger where it is vaporized prior to mixing with air supplied at the same pressure. The steam/air mix is combined with hydrocarbon fuel (represented by dodecane) through a nozzle, prior to delivery to the ATR. The ATR is represented as an adiabatic reactor yielding an equilibrium product distribution. The hot ATR product serves as the heat source for vaporizing the feed water. This is a benefit because it allows low temperature valving to be used to control the reformate flows.

[0048] Typically, the feed O/C ratio was fixed and two convergence criteria were imposed on the simulation. The first required that the temperature of the steam exiting the heat exchanger was sufficient to achieve a specified ATR mixed feed temperature (300°C – 400°C). The second required that the temperature of the cooled ATR product leaving the heat exchanger be compatible with effective sulfur removal in a downstream ZnO bed (typically 300° – 350°C). This was controlled by regulating the water feed rate. Thus, for a given O/C, the S/C ratio was that value which simultaneously satisfied these two requirements. Case studies showed that there was a preferred O/C range (~1.1 – 1.2) below which target ATR feed temperatures could not be achieved and above which system efficiencies declined excessively. As an example, at a fixed O/C of 1.2, acceptable operation for a 400°C target ATR feed temperature and a 300°C ATR product temperature exiting the heat exchanger, could be obtained at a feed S/C of 2.16. The resultant LHV based thermal efficiency for these conditions was ~75% for the reforming system (including BOP parasitics but not including fuel-cell efficiency). Without a fuel cell, heat integration was relaxed in the system prototype. Integration of heat and water-recovery from the downstream SOFC will be required when operating with the stack.

[0049] Although the invention has been described in considerable detail with respect to reactively converting a liquid fuel into a gasified stream by partial oxidation and steam reforming, it will be apparent that the invention is capable of numerous modifications and variations, apparent to those skilled in the art, without departing from the scope of the invention.

What is Claimed:

1. A process for gasification of a liquid fuel comprising:

   (a) providing a supply of the liquid fuel;
   (b) providing a supply of an oxidant;
   (c) providing a supply of liquid water;
   (d) atomizing the liquid fuel through a nozzle into a mixer such that the fuel entering the nozzle and before exiting the nozzle is maintained at a temperature below the coking temperature of the fuel;
   (e) feeding the oxidant into the mixer and mixing the atomized fuel with the oxidant;
   (f) catalytically reacting the fuel-oxidant mixture in the presence of steam in a catalytic reactor thereby producing gaseous reformate; wherein the catalytic reactor comprises a substrate in a coiled configuration having an inner diameter and an outer diameter and a radial flow path, and having supported thereon one or more Group VIII metals;
   (g) initiating the catalytic reaction of step (f) with an ignition source positioned inside the inner diameter of the coiled substrate;
   (h) contacting the gaseous reformate with a heat exchanger positioned downstream of and in fluid communication with the catalytic reactor, such that a hot side of the heat exchanger contacts the gaseous reformate and a cold side of the heat exchanger contacts the supply of water; and further such that the heat exchanger is displaced radially with respect to a center axis of the catalytic reactor and wherein the gaseous reformate exits through the radial flow path of the catalytic reactor and contacts the heat exchanger in a crossflow direction;
   (i) transferring heat from the gaseous reformate via the heat exchanger to the liquid water to produce steam; and
   (j) providing the steam to the fuel-oxidant mixture in the catalytic reaction of step (f).

2. The process of claim 1 wherein the liquid fuel comprises hydrocarbons.

3. The process of claim 1 wherein the oxidant is a constituent of air.

4. The process of claim 1 wherein the step of mixing the atomized fuel with the

oxidant further comprises forming a fuel rich fuel oxidant mixture.

5. The process of claim 1 wherein step (f) further comprises providing a plurality of the substrates thereby providing void volumes in random order.

6. The process of claim 1 wherein the substrate is mounted to avoid bypass of the substrate by the fuel oxidant mixture.

7. The process of claim 1 wherein the step of providing an ignition source for initiating the catalytic reaction further comprises providing a glow plug.

8. The process of claim 1 wherein the step of catalytically reacting the fuel oxidant mixture includes vaporizing and partially oxidizing the fuel oxidant mixture.

9. The process of claim 1 comprising the additional step of:
   (k) positioning a sulfur removal bed in fluid communication with the heat exchanger; and
   (l) passing the gaseous reformate through the sulfur removal bed.

10. The process of claim 1 wherein oxygen to carbon (O/C) is provided at a ratio that ranges from 1.1 to 1.2.

11. The process of claim 3 wherein the steam, the fuel and air is provided at a temperature ranging from 300°C to 400°C.

12. The process of claim 1 wherein the reformate exiting the heat exchanger is at a temperature ranging from 300°C to 350°C.

13. A system for converting a liquid fuel into a gasified stream, the system comprising:
   (a) a nozzle having an outlet for feeding a fuel and an oxidant into contact with a reforming catalyst;
   (b) a fuel inlet for feeding the fuel into the nozzle;
   (c) an oxidant inlet for feeding the oxidant into the nozzle;
   (d) the reforming catalyst positioned downstream from the outlet of the nozzle, the catalyst being supported on a substrate comprising a metal screen in a coiled configuration having an inner diameter and an outer diameter and a radial flow path;
   (e) an ignition source located inside the inner diameter of the metal screen for igniting the catalyst;
   (f) a heat exchanger placed within the system downstream of the catalyst such

that a hot side of the heat exchanger is in fluid communication with the catalyst and a cold side of the heat exchanger is in fluid communication with a supply of water so as to produce steam; and further such that the heat exchanger is displaced radially with respect to a center axis of the coiled metal screen and the heat exchanger has a flow path positioned in crossflow direction with respect to the radial flow path of the coiled metal screen;

(g) a means for feeding steam into contact with the catalyst.

14. The system of claim 13 wherein the nozzle is selected from pressure atomization, air blast, ultrasonic atomization and electrospray nozzles.

15. The system of claim 13 or 14 further comprising an autothermal reactor.

16. The system of any one of claims 13 to 15 wherein the fuel comprises diesel fuel.

17. The system of any one of claims 13 to 16 wherein the oxidant comprises oxygen as a constituent of air.

18. The system of any one of claims 13 to 17 wherein the catalyst comprises a Group VIII metal catalyst supported on the metal screen.

19. The system of claim 18 wherein the Group VIII metal catalyst comprises rhodium.

20. The system of any one of claims 13 to 19 wherein the ignition source comprises a glow plug.

21. The system of any one of claims 13 to 20 further comprising a desulfurization bed positioned downstream from the catalyst and in fluid communication with the heat exchanger.

22. The system of any one of claims 13 to 21 wherein the metal screen in coiled configuration comprises a multiplicity of void volumes in random order.

23. The process of claim 1, wherein the fuel is selected from gasoline, kerosene, diesel and JP-8.

24. The system of claim 13, wherein the fuel is selected from gasoline, kerosene, diesel and JP-8.

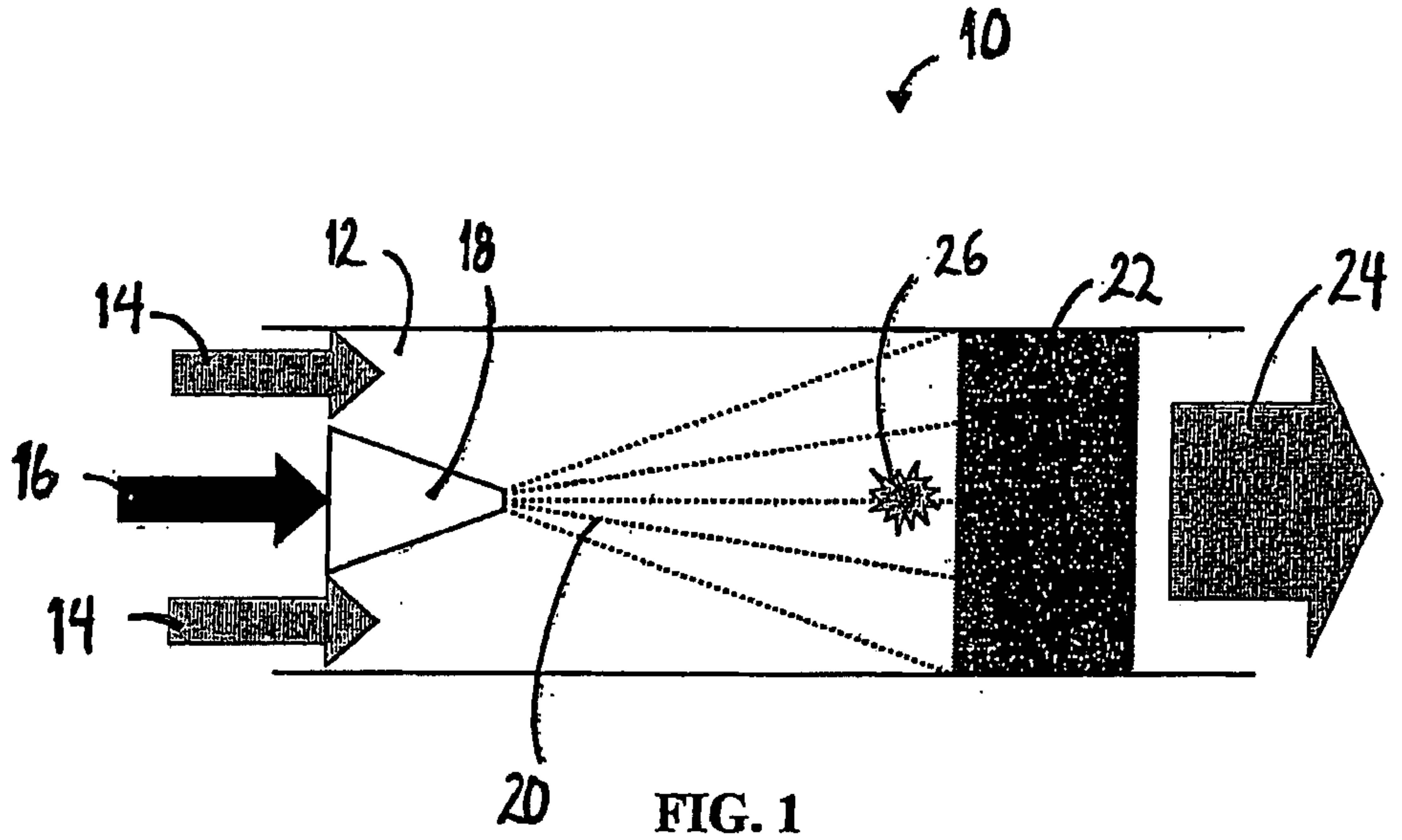
10
12
18
26
22
24
14
16
14
20

FIG. 1

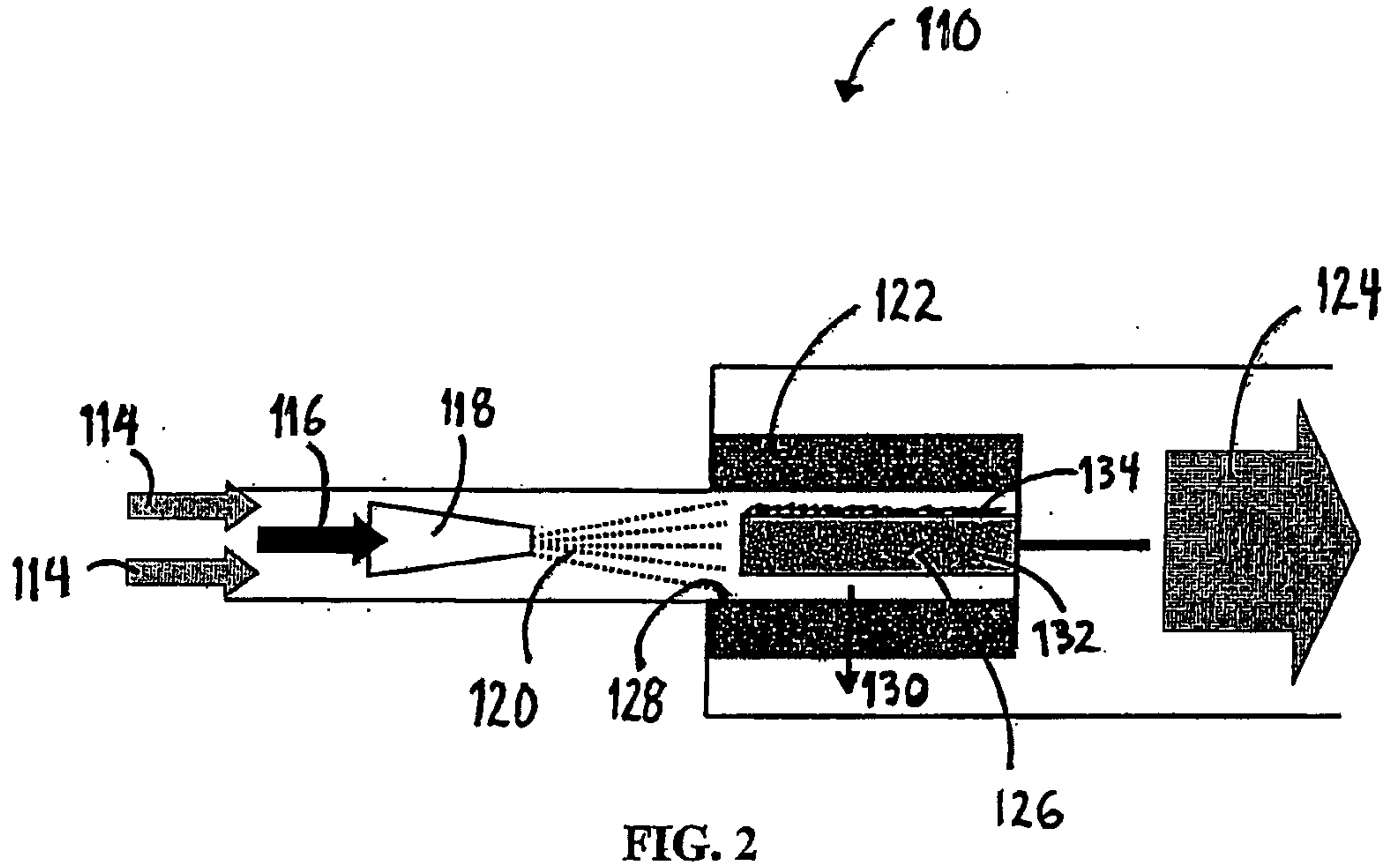
110
122
124
114
116
118
134
114
132
120
128
130
126

FIG. 2

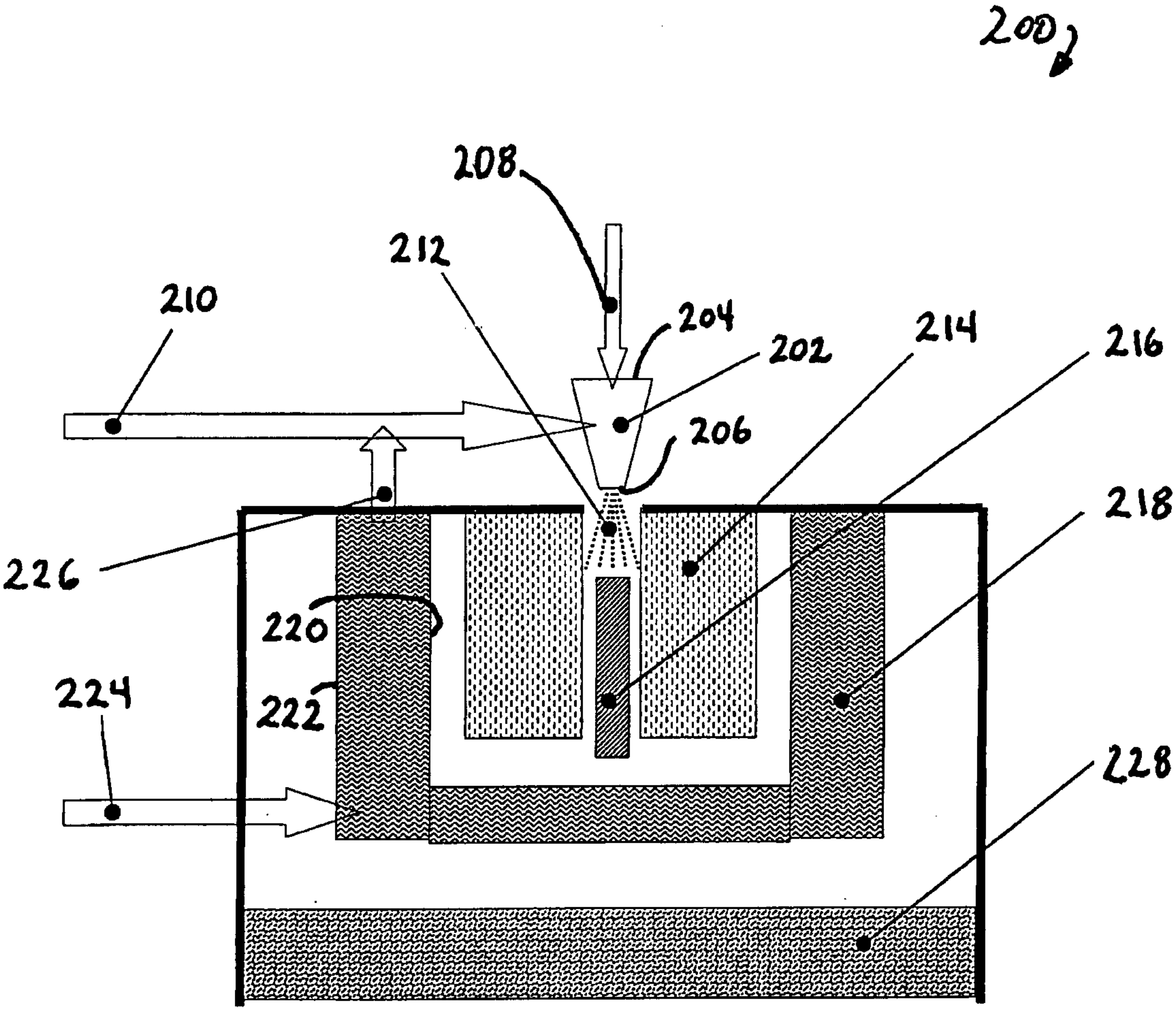

FIG. 3

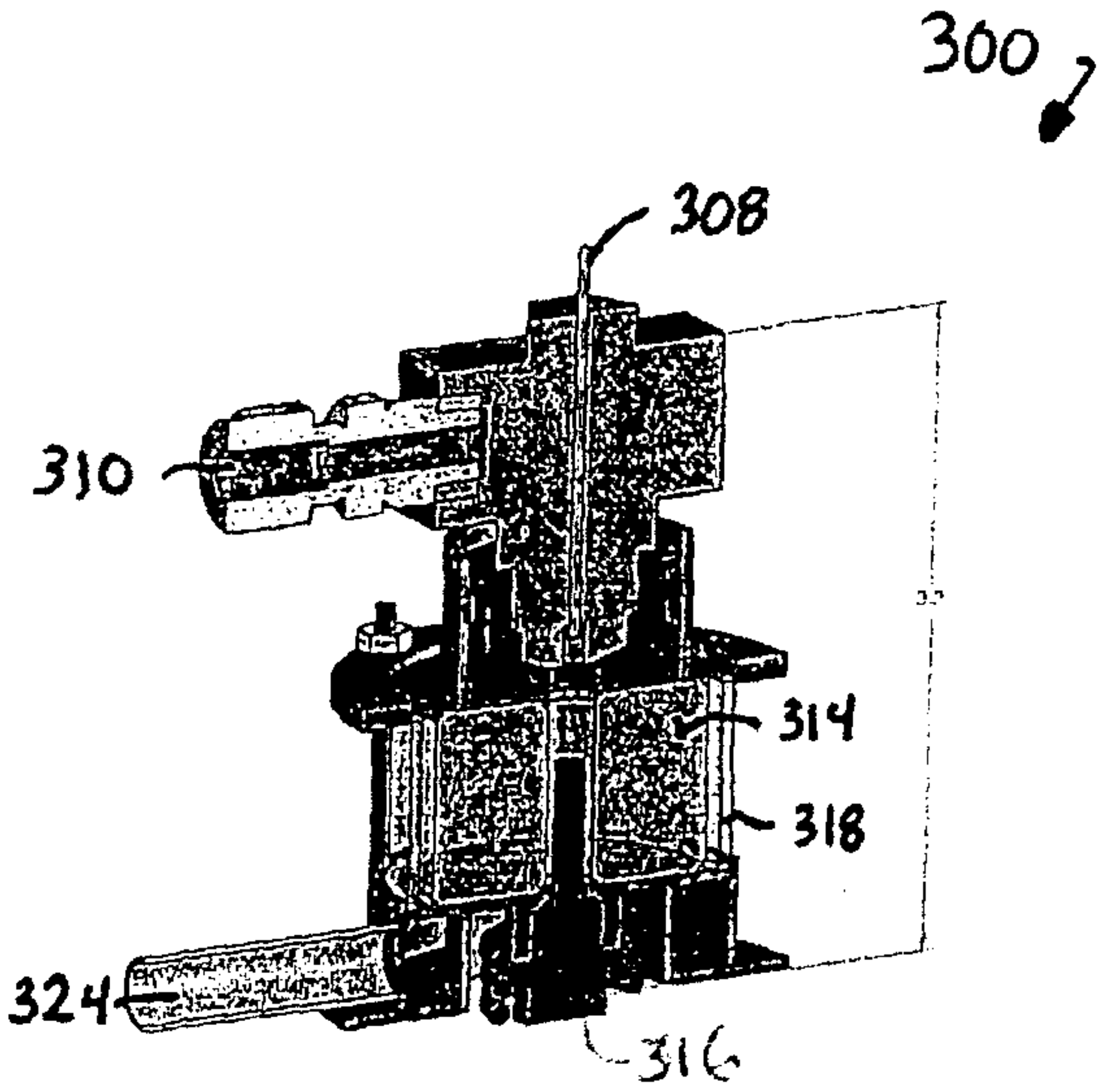

FIG. 4A

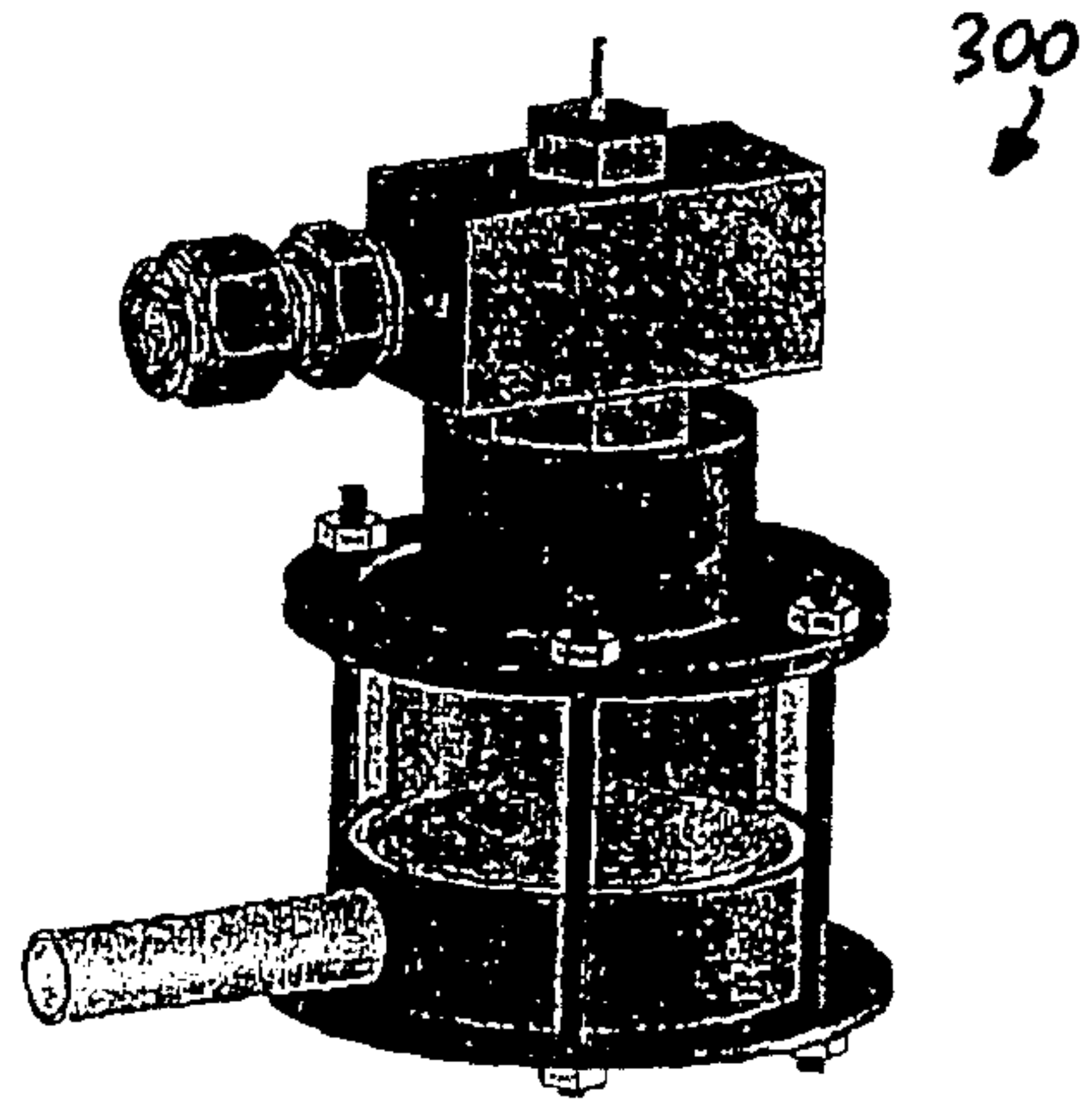

FIG. 4B

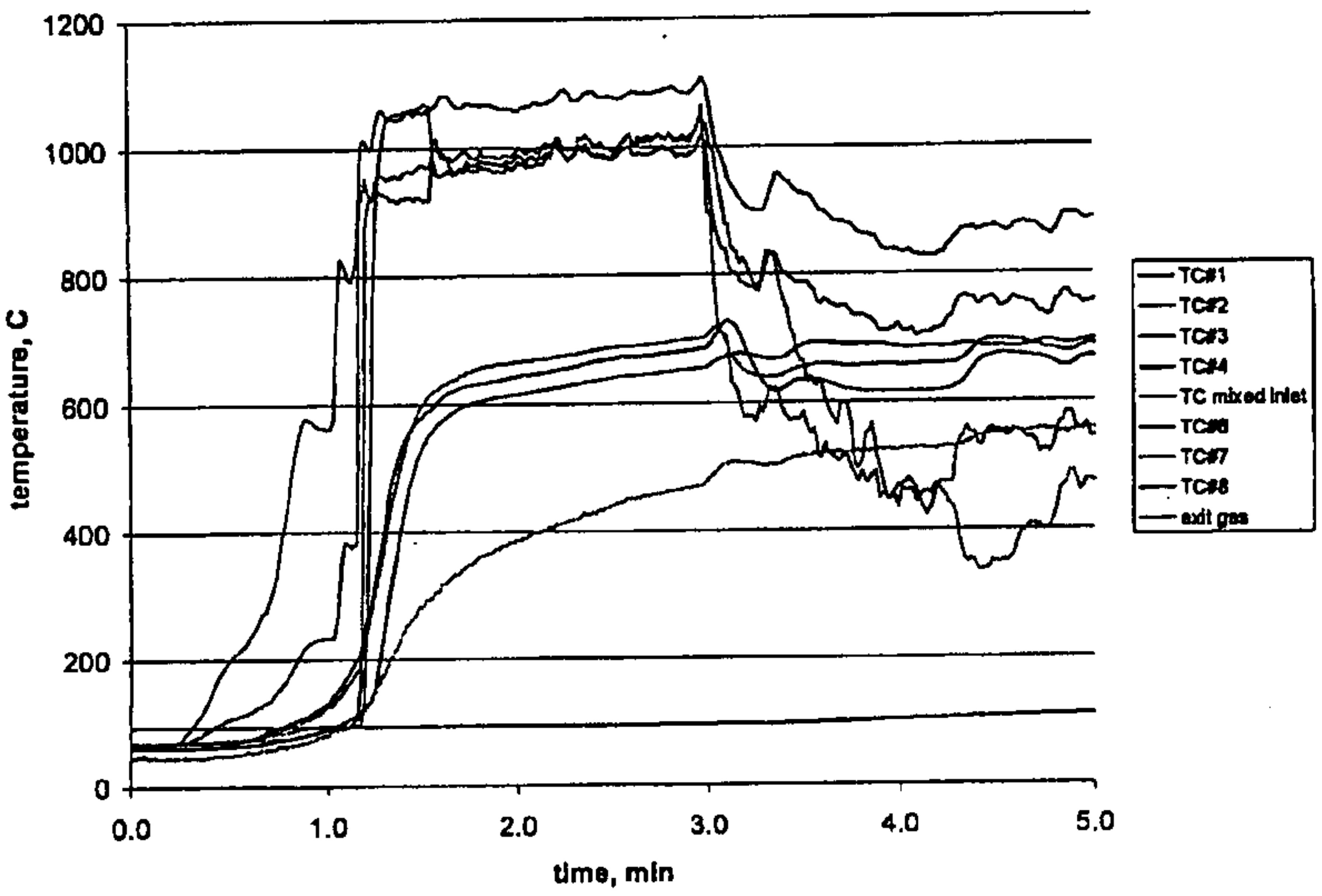
1200
1000
800
600
400
200
0
temperature, C
0.0
1.0
2.0
3.0
4.0
5.0
time, min
TC#1
TC#2
TC#3
TC#4
TC mixed inlet
TC#6
TC#7
TC#8
exit gas

FIG. 5

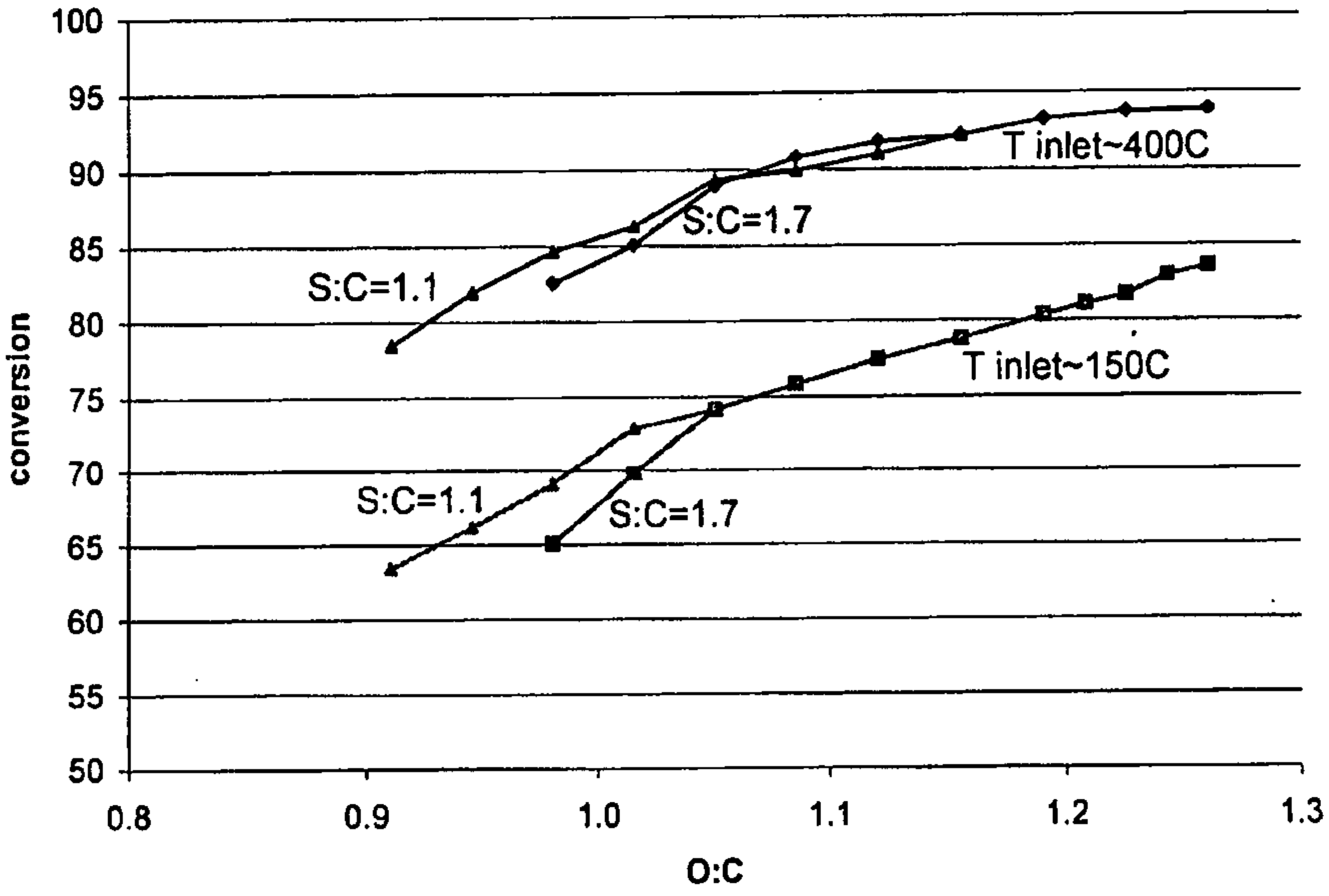
100
95
90
85
80
75
70
65
60
55
50
conversion
0.8
0.9
1.0
1.1
1.2
1.3
O:C
T inlet~400C
S:C=1.7
S:C=1.1
T inlet~150C
S:C=1.1
S:C=1.7

FIG. 6

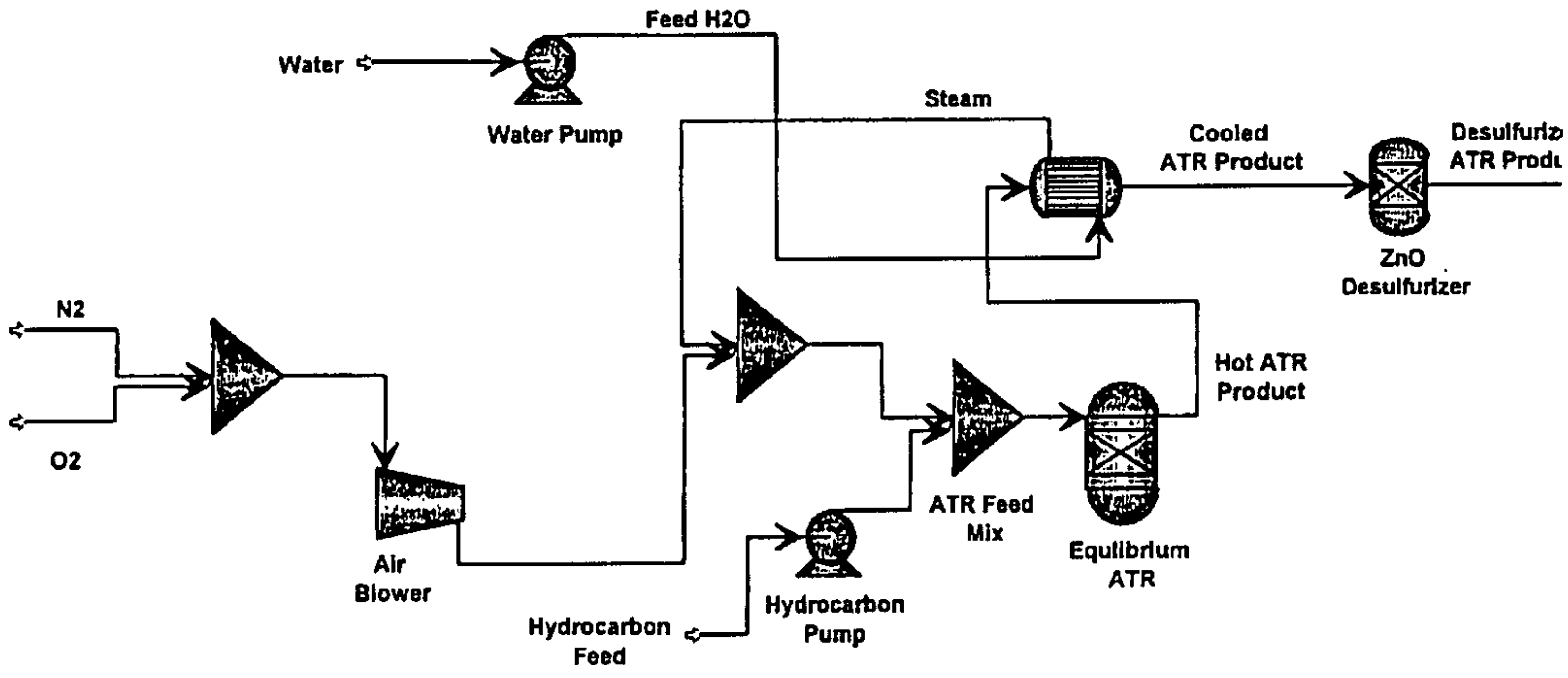
Feed H2O
Water
Water Pump
Steam
Cooled ATR Product
Desulfuriz
ATR Prod
ZnO Desulfurizer
N2
O2
Hot ATR Product
ATR Feed Mix
Equlibrium ATR
Air Blower
Hydrocarbon Feed
Hydrocarbon Pump

FIG. 7