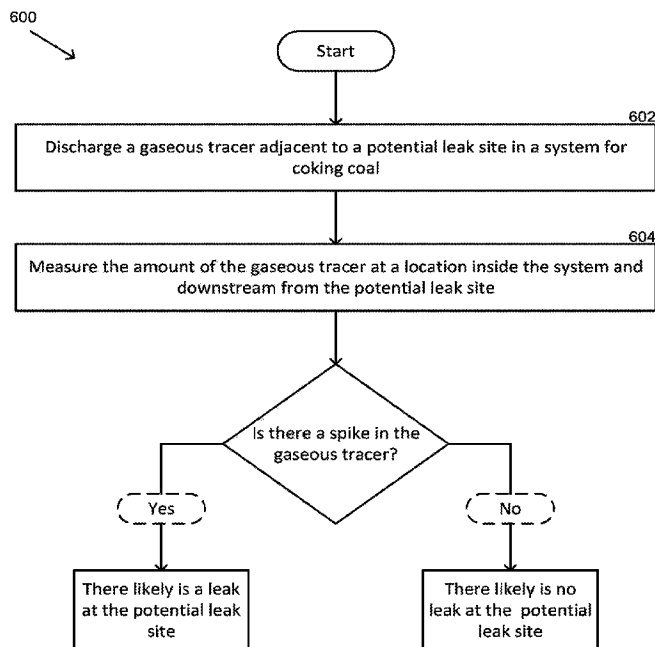




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(54) Title: GASEOUS TRACER LEAK DETECTION



(57) Abrégé/Abstract:

The present technology provides systems and methods for detecting leaks in a coke plant. In some embodiments, the present technology includes discharging a gaseous tracer adjacent to a surface that at least partially divides a high-pressure system and a low-pressure system. The gaseous tracer can be measured at a location within and/or downstream from the low-pressure system to identify leaks in the structure.

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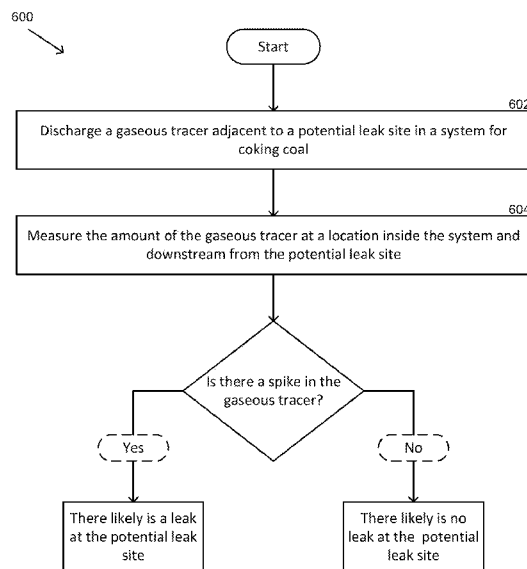


FIG. 6

(57) Abstract: The present technology provides systems and methods for detecting leaks in a coke plant. In some embodiments, the present technology includes discharging a gaseous tracer adjacent to a surface that at least partially divides a high-pressure system and a low-pressure system. The gaseous tracer can be measured at a location within and/or downstream from the low-pressure system to identify leaks in the structure.

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GASEOUS TRACER LEAK DETECTION

CROSS REFERENCE TO RELATED APPLICATION(S)

[0001] The present application claims priority to U.S. Provisional Patent Application No. 62/785,728, titled “GASEOUS TRACER LEAK DETECTION,” filed December 28, 2018; U.S. Provisional Patent Application No. 62/786,096, titled “SYSTEMS AND METHODS FOR TREATING A SURFACE OF A COKE PLANT,” filed December 28, 2018; U.S. Provisional Patent Application No. 62/786,157, titled “COKE PLANT TUNNEL REPAIR AND FLEXIBLE JOINTS,” filed December 28, 2018; and U.S. Provisional Patent Application No. 62/786,194, titled “COKE PLANT TUNNEL REPAIR AND ANCHOR DISTRIBUTION,” filed December 28, 2018.

TECHNICAL FIELD

[0002] The present technology generally relates to systems for coking coal, and in particular to systems and methods for detecting a leak in a system for coking coal.

BACKGROUND

[0003] Coke is a solid carbon fuel and carbon source used to melt and reduce iron ore in the production of steel. Coking ovens have been used for many years to convert coal into metallurgical coke. In one process, coke is produced by batch feeding pulverized coal to an oven that is sealed and heated to very high temperatures for 24 to 48 hours under closely-controlled atmospheric conditions. During the coking process, the finely crushed coal devolatilizes and forms a fused mass of coke having a predetermined porosity and strength. Because the production of coke is a batch process, multiple coke ovens are operated simultaneously.

[0004] One style of coke plants includes Horizontal Heat Recovery (HHR) ovens, which have a unique environmental advantage over chemical byproduct ovens based upon a relative operating atmospheric pressure condition inside the oven. HHR ovens operate under negative pressure, whereas chemical byproduct ovens operate at a slightly positive atmospheric pressure. Both oven types are typically constructed of refractory bricks and other materials in which creating a generally airtight environment

can be a challenge because small cracks can form in these structures, thereby allowing air to leak in or out of the oven. Cracks may also form in structures fluidly coupled to the ovens, exacerbating the challenge of creating an airtight environment. In coke plants operating under a negative pressure, such cracks may permit uncontrolled air to leak into the system, thereby affecting the overall functionality of the coke plant. And in coke plants operating under a positive pressure, such cracks may permit gases to escape from the plant before being treated, thereby making it more difficult to control the coking conditions and increasing the environmental footprint of the coke plant.

[0005] Accordingly, identifying leaks so they can be repaired is an important step in maintaining a functioning coke plant. Current leak detection methods are suboptimal for a variety of reasons. For example, current leak detection methods do not allow a user to quantitatively analyze the size of leaks, and therefore do not allow users to prioritize repair of troublesome leaks. Furthermore, leaks in certain locations (e.g., in an insulated chamber, in the sole flue, etc.) may be difficult and/or not possible to locate with current methods.

BRIEF DESCRIPTION OF THE DRAWINGS

[0006] FIG. 1 is an isometric, partial cut-away view of a portion of a horizontal heat recovery coke plant configured in accordance with select embodiments of the present technology.

[0007] FIG. 2A is an isometric, partial cut-away view of a portion of a byproduct coke oven battery configured in accordance with select embodiments of the present technology.

[0008] FIG. 2B is a schematic illustration of a byproduct coke plant, including the byproduct coke oven battery illustrated in FIG. 2A, configured in accordance with select embodiments of the present technology.

[0009] FIG. 3 is a schematic illustration of a heat recovery coke plant configured in accordance with select embodiments of the present technology.

[0010] FIG. 4 is a schematic illustration of a gaseous tracer spray probe configured in accordance with one embodiment of the present technology.

[0011] FIG. 5 is a schematic illustration of another gaseous tracer spray probe configured in accordance with another embodiment of the present technology.

[0012] FIG. 6 is a flowchart of a method 600 of detecting an air leak in a system for coking coal and in accordance with select embodiments of the present technology.

[0013] FIG. 7 is a flowchart of a method 700 of detecting an air leak in a system for coking coal and in accordance with select embodiments of the present technology.

[0014] FIG. 8 is a flowchart of a method 800 of detecting an air leak in a system for coking coal and in accordance with select embodiments of the present technology.

[0015] FIG. 9 is a flowchart of a method 900 of detecting an air leak in a system for coking coal and in accordance with select embodiments of the present technology.

[0016] FIG. 10 is a flowchart of a method 1000 of detecting an air leak in a system for coking coal and in accordance with select embodiments of the present technology.

[0017] FIG. 11 is a flowchart of a method 1100 of detecting an air leak in a system for coking coal and in accordance with select embodiments of the present technology.

[0018] FIG. 12 is a flowchart of a method 1200 of detecting an air leak in a system for coking coal and in accordance with select embodiments of the present technology.

[0019] FIG. 13 is a flowchart of a method 1300 of detecting an air leak in a system for coking coal and in accordance with select embodiments of the present technology.

[0020] FIG. 14 is a flowchart of a method 1400 of detecting an air leak in a system for coking coal and in accordance with select embodiments of the present technology.

[0021] FIG. 15 is a flowchart of a method 1500 of detecting an air leak in a system for coking coal and in accordance with select embodiments of the present technology.

[0022] FIG. 16 is a flowchart of a method 1600 of detecting a leak between a high-pressure system and a low-pressure system.

[0023] FIG. 17 is a flowchart of a method 1700 of detecting a leak between a high-pressure system and a low-pressure system.

[0024] FIG. 18 is a graphical illustration of the results of a first gaseous tracer leak detection test performed in accordance with embodiments of the present technology.

[0025] FIG. 19 is a graphical illustration of the results of a second gaseous tracer leak detection test performed in accordance with embodiments of the present technology.

DETAILED DESCRIPTION

[0026] The present technology provides systems and methods for detecting leaks in a system for coking coal (e.g., a coke plant). The system and methods can include discharging a gaseous tracer at a first location adjacent to a potential leak site (e.g., a “test” location) in the coke plant, and, after discharging the gaseous tracer at the test location, measuring an amount of the gaseous tracer at a location downstream of the test location (e.g., at a second location with a lower pressure than the first location). The downstream location can be at least partially fluidly isolated from the test location under normal, non-leaking, operating conditions. Measuring a spike in the concentration of the gaseous tracer at the location downstream of the potential leak site can therefore indicate that there is a leak at the test location. As discussed in greater detail below, the present technology be used to detect leaks in a number of different coke plant systems, including chemical byproduct coke plants (“byproduct system”), heat recovery coke plants (“heat recovery system”), beehive/non-recovery coke plants (“non-recovery system”), and other types of coke plants known in the art.

[0027] Coke plants have a number of different structures that may be susceptible to forming leaks. For example, coke system(s) generally have a plurality of coke ovens for heating coal to produce coke. In some embodiments, coke systems may also include one or more flue gas chambers, a plurality of heat recovery steam generators, a common tunnel fluidly coupled to the plurality of coke ovens and/or the plurality of heat recovery steam generators, and/or other features common to coke plants known in the art. Due to a variety of reasons, various structures and/or surfaces in the coke plant may be susceptible to cracking or other wear that permits an airflow between the external environment and the interior of the system, or vice versa. Such airflow may be problematic, for example, because it can make it challenging to maintain a desired pressure inside the system, can make it challenging to maintain a suitable temperature for coking coal, and can adversely affect the quality of coke produced by the system. The uncontrolled airflow may also increase the environmental footprint of certain coke plants. Accordingly, the present technology provides systems and methods for detecting leaks that permits air to enter or leave the coking system in an uncontrolled and/or undesired manner, or otherwise affects the performance of the coke plant. More specifically, as will be described in detail herein, select embodiments of the present technology can, among other things, (1) identify whether a leak exists, (2) identify a

location of a leak, and/or (3) at least semi-quantitatively analyze the size of the leak. Identifying cracks enables the cracks to be repaired, patched, or otherwise treated to mitigate and/or eliminate the foregoing problems, among other things. In some embodiments, the present technology enables leaks to be detected without reducing the temperature of the coking plant or taking the coking plant "offline" (i.e., the test can be performed without interrupting the operation of the coke plant). For example, in some embodiments the tests described herein can be performed in systems having temperatures of 100 degrees Celsius or higher, 500 degrees Celsius or higher, 1,000 degrees Celsius or higher, and/or 1,500 degrees Celsius or higher, thereby allowing the tests to be performed without interrupting the coking cycle.

[0028] As will be described in greater detail below, the present technology can be applied to any number of coke plants, including, for example, heat recovery coking systems and byproduct coking systems. For example, for heat recovery systems, several embodiments of the present technology include discharging a gaseous tracer adjacent to an external facing surface of the coke plant. If there is a leak between the external facing surface and the interior of the coke plant, the negative pressure of the heat recovery system will draw the gaseous tracer into the coke plant. Accordingly, the amount of gaseous tracer inside the heat recovery system may be measured at a location downstream of the tested external facing surface to determine if gaseous tracer discharged at the potential leak site entered the heat recovery system. If a spike in gaseous tracer is observed at the downstream location inside the heat recovery system, there is likely a leak on the tested surface. This process may be repeated at any number of potential leak sites. Likewise, in byproduct coking systems, several embodiments of the present technology include discharging a gaseous tracer into a high-pressure environment adjacent a low-pressure environment. If there is a leak between the high-pressure environment and the low-pressure environment, the gaseous tracer will be detected in the low-pressure environment.

[0029] As will be discussed in detail herein, the present system is beneficial because, among other things, it can at least partially quantitatively characterize leaks and locate leaks in locations where traditional methods cannot. For example, the present technology allows coke plant operators to prioritize repair of more troublesome leaks based on the provided quantitative analysis. Furthermore, the present technology enables identification of leaks in locations that were previously difficult to test, such as

insulated regions of the system or in the sole flue. The present technology, for example, is capable of identifying regions that do not have a direct leak into the interior of the system, but instead allow air into a region between an outer surface and insulation. This air may be problematic because it can migrate beneath the insulation and enter the system at a different location.

[0030] Specific details of several embodiments of the disclosed technology are described below with reference to particular, representative configurations. The disclosed technology can be practiced in accordance with coke making systems having other suitable configurations. Specific details describing structures or processes that are well-known and often associated with coke making systems but that can unnecessarily obscure some significant aspects of the present technology are not set forth in the following description for clarity. Moreover, although the following disclosure sets forth some embodiments of the different aspects of the disclosed technology, some embodiments of the technology can have configurations and/or components different than those described in this section. As such, the present technology can include some embodiments with additional elements and/or without several of the elements described below with reference to FIGS. 1–17.

[0031] As used herein, the terms “coke plants”, “coking plants”, “coke systems,” “coking systems,” “systems for coking coal,” and their variants collectively refer to any type of coke plant, including byproduct coke plants, heat recovery coke plants, horizontal heat recovery coke plants, non-recovery coke plants, and horizontal non-recovery coke plants. Moreover, certain aspects of the present disclosure are described in the context of a specific oven type. However, as one skilled in the art will appreciate, such aspects may be readily adapted for use with any type of coke plant. Accordingly, aspects of the present disclosure is not limited to a specific type of coke plant, unless explicitly noted otherwise.

[0032] As used herein, the terms “high-pressure system” and “low-pressure system” are used in a relative manner. Neither the “high-pressure system” nor the “low-pressure system” require a pressure above or below a specific magnitude. Rather, the term “high-pressure system” is used to mean that the system has a pressure that is greater than a pressure in another adjacent system (e.g., a low-pressure system). Likewise, the term “low-pressure system” is used to mean that the system has a

pressure that is less than a pressure in another adjacent system (e.g., a high-pressure system).

[0033] As used herein, the terms “upstream” and “downstream” refer to the expected direction of gas flow in a coke plant. For example, gas is expected to flow in a direction from an upstream structure to a downstream structure.

[0034] As used herein, the term “residence time” refers to the duration of time that it takes for a gas to travel between two locations. For example, the first location can be any test location and the second location can be any location where measurements are taken.

[0035] Reference throughout this specification to relative terms such as, for example, “generally,” “approximately,” and “about” are used herein to mean the stated value plus or minus 10%. For example, the term “about 100” refers to a range from 90 to 110, inclusive.

[0036] Referring to FIG. 1, a coke plant 100 is illustrated which produces coke from coal in a reducing environment. In general, the coke plant 100 comprises at least one oven 101, along with heat recovery steam generators and an air quality control system (e.g. an exhaust or flue gas desulfurization system) both of which are positioned fluidly downstream from the ovens and both of which are fluidly connected to the ovens by suitable ducts. According to aspects of the disclosure, the coke plant can include a heat recovery or a non-heat recovery coke oven, or a horizontal heat recovery or horizontal non-recovery coke oven. The coke plant 100 preferably includes a plurality of ovens 101 and a common tunnel 102 that is fluidly connected to each of the ovens 101 with uptake ducts 103. A cooled gas duct transports the cooled gas from the heat recovery steam generators to the flue gas desulfurization system. Fluidly connected and further downstream are a baghouse for collecting particulates, at least one draft fan for controlling air pressure within the system, and a main gas stack for exhausting cooled, treated exhaust to the environment. Steam lines interconnect the heat recovery steam generators and a cogeneration plant so that the recovered heat can be utilized. The coke plant 100 can also be fluidly connected to a bypass exhaust stack 104 that can be used to vent hot exhaust gasses to the atmosphere in emergency situations.

[0037] FIG. 1 illustrates four ovens 101 with sections cut away for clarity. Each oven 101 comprises an oven chamber 110 preferably defined by a floor 111, a front

door 114, a rear door 115 preferably opposite the front door 114, two sidewalls 112 extending upwardly from the floor 111 intermediate the front 114 and rear 115 doors, and a crown 113 which forms the top surface of the oven chamber 110. Controlling air flow and pressure inside the oven 101 can be critical to the efficient operation of the coking cycle and therefore the oven 101 includes one or more air inlets 119 that allow air into the oven 101. Each air inlet 119 includes an air damper which can be positioned at any number of positions between fully open and fully closed to vary the amount of primary air flow into the oven 101. In the illustrated embodiment, the oven 101 includes an air inlet 119 coupled to the front door 114, which is configured to control air flow into the oven chamber 110, and an air inlet 119 coupled to a sole flue 118 positioned beneath the floor 111 of the oven 101. Alternatively, the one or more air inlets 119 are formed through the crown 113 and/or in the uptake ducts 103. In operation, volatile gases emitted from the coal positioned inside the oven chamber 110 collect in the crown 113 and are drawn downstream in the overall system into downcomer channels 117 formed in one or both sidewalls 112. The downcomer channels 117 fluidly connect the oven chamber 110 with the sole flue 118. The sole flue 118 forms a circuitous path beneath the floor 111 and volatile gases emitted from the coal can be combusted in the sole flue 118, thereby generating heat to support the reduction of coal into coke. The downcomer channels 117 are fluidly connected to uptake channels 116 formed in one or both sidewalls 112. The air inlet 119 coupled to the sole flue 118 can fluidly connect the sole flue 118 to the atmosphere and can be used to control combustion within the sole flue 118. The oven 101 can also include a platform 105 adjacent to the front door 114 that a worker can stand and walk on to access the front door and the oven chamber 110.

[0038] In operation, coke is produced in the ovens 101 by first loading coal into the oven chamber 110, heating the coal in an oxygen depleted environment, driving off the volatile fraction of coal and then oxidizing the volatiles within the oven 101 to capture and utilize the heat given off. The coal volatiles are oxidized within the ovens over a 48-hour coking cycle and release heat to regeneratively drive the carbonization of the coal to coke. The coking cycle begins when the front door 114 is opened and coal is charged onto the floor 111. The coal on the floor 111 is known as the coal bed. Heat from the oven (due to the previous coking cycle) starts the carbonization cycle. Preferably, no additional fuel other than that produced by the coking process is used.

Roughly half of the total heat transfer to the coal bed is radiated down onto the top surface of the coal bed from the luminous flame and radiant oven crown 113. The remaining half of the heat is transferred to the coal bed by conduction from the floor 111, which is convectively heated from the volatilization of gases in the sole flue 118. In this way, a carbonization process "wave" of plastic flow of the coal particles and formation of high strength cohesive coke proceeds from both the top and bottom boundaries of the coal bed at the same rate, preferably meeting at the center of the coal bed after about 45-48 hours.

[0039] Any of a number of structures, locations, connections, and/or surfaces within the coke plant 100 may be susceptible to leaks. Leaks may form, for example, in the sole flue 118, in the front door 114, in the air inlet 119, in the uptake ducts 103, and/or in the common tunnel 102. Other locations not explicitly mentioned herein may also be susceptible to leaks. Leaks may form, for example, if one or more cracks extend between an external facing surface and an internal facing surface of the coking system. Leaks may also occur at connective joints. When the coke plant 100 is operating under a negative pressure, such as in a heat recovery system, a leak will allow uncontrolled air to enter into the coke plant 100, thereby affecting the functionality of the coke plant 100. Accordingly, there is a need to test for and identify leaks in the coke plant 100. Thus, a probe 120 is provided to test for leaks at potential leak sites. As will be described in detail herein, the probe 120 is configured to detect leaks in the coke plant 100 by dispensing a gaseous tracer adjacent to a potential leak site.

[0040] FIG. 2A illustrates a coke oven battery 200 of a byproduct coke plant. The coke oven battery 200 includes a plurality of narrow, vertically oriented coke ovens 202. During operation, coal is loaded into the ovens 202 and heated in a reducing atmosphere to vaporize the volatiles into a raw coke gas. The raw coke gas is transported to a by-product plant for treatment, as will be described in greater detail below. The remaining coke mass is pushed from the oven and can be wet or dry quenched prior to its shipment to a blast furnace for further processing, as known in the art.

[0041] The coke ovens 202 are heated via burning gaseous fuel and allowing the heated gases to occupy flue chambers 204 positioned around the ovens 202. In some embodiments, each oven 202 can share a common heating flue chamber 204 with an

adjacent oven 202. The plant 200 can further include a waste gas tunnel 206 and a plurality of ducts 208 fluidly connecting the flue chambers 204 and the waste gas tunnel 206. The gaseous fuel can be combusted adjacent the flue chambers 204 to generate hot flue gas that can enter the flue chambers 204 and heat the coke ovens 202. The flue gas can then enter the waste gas tunnel 206 via the plurality of ducts 208 and be transported to an exhaust stack (not shown).

[0042] The coke oven battery 200 also includes a plurality of raw coke gas vents 210 fluidly connected to the oven chambers 202. After raw coke gas is vaporized from the heated coal in the oven chambers 202, the raw coke gas vents transport the raw gas from the oven chambers 202 to a main collector channel 212. The main collector channel 212 delivers the raw coke gas vents to a byproduct treatment plant, as described in detail with respect to Fig. 2B. The raw coke oven gas can include a mixture of water vapor, hydrogen methane, nitrogen, carbon monoxide, carbon dioxide, and/or various hydrocarbons. Raw coke oven gas can also include tar vapors, light oil vapors, naphthalene, vapor, ammonia gas, hydrogen sulfide gas, hydrogen cyanide gas, and/or other contaminants in various amounts. Typically, the raw coke gas is treated in a byproduct treatment plant to transform the raw gas into environmentally friendly fuel gases.

[0043] FIG. 2B is a schematic illustration of the coke oven battery 200 operably coupled to the byproduct coke plant 250 for processing the raw coke oven gas. As illustrated, the byproduct coke plant 250 receives raw coke gas via the main collector channel 212. As raw coke gas exits the byproduct coke plant 202, it is cooled by a primary gas cooler (not shown) and passes through a gas condensation chamber 252. The primary gas cooler cools the raw gas to remove water vapor. Suitable primary gas coolers include spray type coolers and horizontal tube type coolers. As the raw gas is cooled, the water, tar, and naphthalene condense out, leaving behind a condensate in the gas condensation chamber 252. The gas next flows through a tar precipitator chamber 254. Tar precipitators can use high voltage electrodes to charge the tar particles in the gas and subsequently capture the tar particles through electrostatic attraction. After flowing through the tar precipitator chamber 254, the gas flows through an ammonia removal chamber 256. Ammonia is removed from the gas in the ammonia removal chamber 256. For example, ammonia can be removed from the gas through contacting the gas with a solution of sulphuric acid to form ammonium sulphate. In

another example, the ammonia is removed from the gas using a solution of mono ammonium phosphate to produce anhydrous ammonia. The gas then flows through a naphthalene collection chamber 258, a benzene collection chamber 260, and a hydrogen sulphide removal chamber (not shown). The cleaned gas can then be stored in a gas holder (not shown). As one skilled in the art will appreciate, however, the design of the byproduct coke plant 250 can be altered to include additional or fewer chambers than expressly illustrated and described herein. Likewise, the various treatment chambers can be arranged such that the raw gases flow through the chambers in any sequence. Such alterations are within the scope of the present technology.

[0044] As with coke plant 100, byproduct coke plant 200 may be susceptible to leaks that can allow air to enter the system and/or gases to uncontrollably flow from a high-pressure location to a low-pressure location. As one skilled in the art will appreciate, the high-pressure location can be internal or external to the coke plant 200, and the low-pressure location can be internal or external to the coke plant 200, depending on the configuration of the plant 200. Leaks may form, for example, in the oven doors, the flue chambers 204, the waste gas tunnel 206, the ducts 208, the raw coke gas vents 210, and/or the main collector channel 212. Leaks may also form under insulation in, for example the flue chambers 204. Other locations not explicitly mentioned herein may also be susceptible to leaks (e.g., in an air space beam area, in a cold duct, by fans, etc.). Leaks may form, for example, if one or more cracks extend between an external facing surface and an internal facing surface of the coking system. Leaks may also occur at connective joints and under/through insulation. When the coke plant 200 is operating under a positive pressure, a leak may allow raw coke oven gas or other pollutants to flow out of the system and into the surrounding environment. Accordingly, there is a need to test for and identify leaks in the coke plant 200. Thus, as illustrated in FIG. 2A, a probe 220 is configured to detect leaks in the coke plant 200 by dispensing a gaseous tracer adjacent to potential leak sites. The probe 220 is configured to detect leaks in the coke plant by dispensing a gaseous tracer adjacent to a potential leak site. Thus, the probe 220 may be moved to any location adjacent to a potential leak site. For example, the probe 220 can be a hand-held probe that a user can carry between potential leak sites. Accordingly, the probe 220 can enable a user to relatively quickly check multiple locations for leaks. As will be described in greater

detail below, the present technology further includes a detector configured to detect the gaseous tracer. The detector can be positioned at any location downstream of the probe 220.

[0045] FIG. 3 is a schematic illustration of a heat recovery coke plant configured to operate under a negative pressure. As illustrated in FIG. 3, a plurality of heat recovery coke ovens 302 are provided for coking coal. The coke ovens 302 are fluidly connected to a plurality of heat recovery steam generators 304 by a common tunnel 306. A cooled gas duct 308 transports cooled gas from the heat recovery steam generators 304 to an air quality control system 310 (e.g., a flue gas desulfurization system). Fluidly connected and further downstream are a baghouse 312 for collecting particulates, at least one draft fan 314 for controlling flue gas pressure within the system, and a main gas stack 316 (e.g., an exhaust stack) for exhausting cooled, treated exhaust to the environment.

[0046] A probe 320 for dispensing a gaseous tracer is illustrated as being positioned adjacent to the plurality of ovens 302. As described herein, the probe is configured to detect leaks in the coke plant by dispensing a gaseous tracer adjacent to a potential leak site. Thus, the probe 320 may be moved to any location adjacent to a potential leak site. For example, the probe 320 can be a hand-held probe that a user can carry between potential leak sites. Accordingly, the probe 320 can enable a user to relatively quickly check multiple locations for leaks. As further illustrated in FIG. 3, the present technology includes a detector 322 configured to detect the gaseous tracer inside the coke plant 320. In FIG. 3, the detector is positioned adjacent to the main gas stack 316. However, in other embodiments, the detector 322 may be positioned at any location downstream of the probe 320.

[0047] Referring to FIG. 2A and FIG. 3, the probes 220, 320 may be any device configured to dispense a gaseous tracer. For example, the probes 220, 320 may include a valve configured to control the release of the gaseous tracer. In some embodiments, the probes 220, 320 may discharge a known volume of the gaseous tracer, a constant volume of the gaseous tracer, or a known and constant volume of the gaseous tracer. The detector 322 may be any device configured to measure an amount of the gaseous tracer. For example, the detector 322 may be a mass spectrometer or other suitable device. In some embodiments, the detector 322 is operably coupled to a

vacuum pump or other mechanism configured to draw air into the sample. The detector can be moveable or fixed. For example, in some embodiments, the detector 322 is a hand-held or other moveable detector and can be carried between multiple locations. In other embodiments, the detector 322 is secured or otherwise affixed to a structure of the coke plant 320. For example, the detector 322 can be temporarily affixed to a structure of the coke plant 320 while a test is performed, or can be affixed to a structure of the coke plant 320 for a longer period (e.g., semi-permanently, permanently, etc.). In some embodiments, the detectors can be moveable to ensure an accurate reading can be taken.

[0048] FIG. 4 illustrates one embodiment of a probe 400. In some embodiments, probes 220, 320 are generally similar to probe 400. The probe 400 includes a proximal end region 402 configured to receive a gaseous tracer from a gaseous tracer supply 420 (e.g., a gas storage canister). For example, the probe 400 can include a hose 403 fluidly coupled to the gaseous tracer supply 420. The probe also includes a distal end region 404, configured to discharge the gaseous tracer. For example, the distal end region 404 can include a spray nozzle 415. Moving in a proximal to distal direction, the probe 400 may include a pressure regulator 406, a gauge 408, a hand valve 410, and a two-way spring valve 412. The pressure regulator 406 may be attached to a gaseous tracer supply 420 and may regulate the amount of gaseous tracer 420 flowing through the probe 400. The gauge may visually depict the pressure in the probe 400. The two-way spring valve 412 can control the discharge of the gaseous tracer through the spray nozzle 415. In some embodiments, the two-way spring valve is a two-way manually operated spring valve.

[0049] FIG. 5 illustrates an embodiment of a known-volume spray probe 500. In some embodiments, probes 220, 320 are generally similar to probe 500. The probe 500 includes a proximal end region 502 configured to receive gaseous tracer from a gaseous tracer supply 520 (e.g., a gas storage canister). For example, the probe 500 can include a hose 503 fluidly coupled to the gaseous tracer supply 420. The probe also includes a distal end region 504 configured to discharge the gaseous tracer. For example, the distal end region 404 can include a spray nozzle 515. Moving in a proximal to distal direction, the probe 500 may include a pressure regulator 506, a first gauge 508, a first hand valve 510, a known volume canister 518, a second gauge 516, a second hand valve 514, and a two-way spring valve 512. Utilizing the pressure

regulator 506, the known volume canister 518 may be filled to a constant pressure and sealed off from the gaseous tracer supply 520. The contents of the known volume canister 518 can be discharged through the two-way spring valve so a known and constant amount of volume is released via the spray nozzle 515. The known volume canister 518 may then be refilled to the same constant pressure, thereby ensuring the volume of gaseous tracer dispensed by the probe 500 remains constant. As one skilled in the art will appreciate from the disclosure herein, other probes suitable for discharging a gaseous substance can be used without deviating from the scope of the present technology.

[0050] A number of gaseous tracers may be suitable for use with the present technology. For example, in some embodiments, the gaseous tracer may be any compound that is not otherwise present in the system and is detectable at a location within the system. In some embodiments, the gaseous tracer may already be present in the system and/or the environment. As will be described below, such tracers can be used because a baseline measurement of the gaseous tracer already present in the system can be taken and adjusted for.

[0051] In some embodiments, the gaseous tracer is a non-combustible tracer (e.g., it is at least partially stable and is not fully degraded in the system). For example, the non-combustible gaseous tracer can comprise any non-reactive molecule or element. Examples of suitable non-reactive gaseous tracers include the noble gases, including but not limited to helium, neon, argon, xenon, and their isotopes. Other examples of suitable gaseous tracers include non-noble gases such as fluorine gas. Yet another example of suitable gaseous tracers are nuclear tracers, such as tritium.

[0052] The gaseous tracer may exhibit certain flow characteristics once mixed with other gases inside the system. For example, in some embodiments, the gaseous tracer may flow through some or generally all of the system with a generally turbulent flow. In other embodiments, the flow of the gaseous tracer may be generally turbulent in at least one region of the system. In some embodiments, the flow of the gaseous tracer through the system may further be characterized by its Reynolds number. For example, in some embodiments, the gaseous tracer may exhibit a Reynolds number of about 4,000 or more, about 10,000 or more, about 25,000 or more, about 50,000 or more, or about 100,000 or more in at least one region of the system. Further, in some embodiments,

the gaseous tracer may also move through the system in a relatively short residence time. For example, depending on the size of the system, the residence time may be 120 seconds or less, 90 seconds or less, 60 seconds or less, 45 seconds or less, 30 seconds or less, and/or 15 seconds or less. As one skilled in the art will appreciate, the flow characteristics depend on, among other things, the conditions adjacent to and within the coking system. However, the present technology provides gaseous tracer tests that work in coking systems that exhibit a wide range of flow characteristics, including in systems having flow characteristics such as turbulent flow, high Reynolds numbers, and/or relatively short residence times.

[0053] FIGS. 6–17 are flowcharts of methods of detecting leaks in accordance with the present technology. To better describe the present technology, certain aspects of the methods are highlighted while discussing specific figures. However, one skilled in the art will recognize that the present technology can include some embodiments with additional elements and/or without several of the elements described below with reference to FIGS. 6–17. Therefore, any step discussed with respect to a method below may be included in any other method unless explicitly stated otherwise. Moreover, descriptions of certain steps previously described in detail may be shortened to avoid unnecessary repetition. One skilled in the art will recognize that many of the methods below include similar steps, and that the description of one step may be equally applicable to another similar step.

[0054] FIG. 6 is a flowchart of a method 600 of detecting an air leak in a system configured to coke coal under a negative pressure. The method 600 begins by discharging a gaseous tracer adjacent to a potential leak site (e.g., any structure at least partially dividing a high-pressure system and a low pressure system) in the system (process step 602). As discussed previously, the potential leak site can be any site in the system that may allow external air to enter into the system in an uncontrolled manner. For example, potential leak sites include, but are not limited to, the sole flues, the oven chambers, the front doors of the ovens, the back doors of the ovens, the air inlets, the uptake ducts, and/or the common tunnel, as well as any connecting joints or ducts between said sites. If the potential leak site includes a leak, the pressure differential between the inside of the system and the external environment will suck gaseous tracer into the system. Once inside the system, the gaseous tracer will move

in a downstream direction away from the leak and towards a downstream location (e.g., an exhaust stack).

[0055] The method 600 continues by measuring the amount of gaseous tracer at a location inside the system and downstream from the potential leak site (process step 604). Measurements may be made by any device suitable to continuously monitor a volume or amount of gaseous tracer (e.g., a mass spectrometer, etc.). Measurements may be made at any location downstream from the potential leak site (e.g., an exhaust stack, a distillation column, etc.). By measuring gaseous tracer at a location downstream from the potential leak site, any gaseous tracer that entered at the potential leak site during step 602 may be detected. Accordingly, detecting a spike in gaseous tracer during step 604 indicates there is likely a leak at the potential leak site. If no spike in gaseous tracer is detected, no gaseous tracer entered the system during step 602, and therefore there likely is not a leak at the potential leak site.

[0056] FIG. 7 is a flowchart of a method 700 of detecting an air leak in a system configured to coke coal under a negative pressure after accounting for any gaseous tracer already present in the system. The method begins by measuring a baseline amount of gaseous tracer at a first location in a system for coking coal (process step 702). The baseline measurement can be made anywhere in the system. For example, the baseline measurement may be taken at a location upstream from the surface to be tested. In other embodiments, the baseline measurement may be taken at a location downstream from or adjacent the surface to be tested. By taking a baseline measurement of the amount of gaseous tracer in the system prior to any testing, the operator can account for any gaseous tracer that may already be present in the system from previous tests and/or from another source, thereby enabling the operator to determine that a subsequent measurement of gaseous tracer is due to a leak allowing gaseous tracer into the system and not previously present gaseous tracer. In some embodiments, the operator may optionally zero the gaseous tracer measuring device such that the baseline amount of gaseous tracer measures as zero on the device. As a consequence, detecting any gaseous tracer in the system during a subsequent gaseous tracer leak test will indicate there is a leak. In other embodiments, the ambient gaseous tracer can be adjusted for after the test.

[0057] Method 700 continues by discharging gaseous tracer adjacent to a potential leak site in the system that is upstream from the first location (process step 704). As discussed previously, the potential leak site can be any site in the system that may allow external air to enter into the system in an uncontrolled manner. For example, potential leak sites include, but are not limited to, the sole flues, the oven chambers, the front doors of the ovens, the back doors of the ovens, the air inlets, the uptake ducts, and/or the common tunnel, as well as any connecting joints or ducts between said sites. If the potential leak site includes a leak, the pressure differential between the inside of the system and the external environment will suck gaseous tracer into the system. Once inside the system, the gaseous tracer will move in a downstream direction away from the potential leak site and towards a downstream location.

[0058] The method 700 continues by continuously measuring the amount of gaseous tracer at the first location for a period beginning when the gaseous tracer is discharged at the potential leak site (process step 706). By measuring gaseous tracer at the first location, any gaseous tracer that entered at the potential leak site during step 704 may be detected. The period may be any period of time approximately equal to the time it takes the gaseous tracer to travel from the potential leak site to the first location. For example, the period may be determined by dividing the distance between the first location and the potential leak site by the average velocity of the gaseous tracer between the first location and the potential leak site. In some embodiments, this time may be 120 seconds or less, 90 seconds or less, 60 seconds or less, 45 seconds or less, 30 seconds or less, and/or 15 seconds or less.

[0059] The method 700 continues by comparing the baseline amount of gaseous tracer with the amount of gaseous tracer observed during the period to determine if there is a leak at the potential leak site (process step 708). If the measuring device has been zeroed out in step 702 such that the baseline reading of gaseous tracer is zero, any gaseous tracer detected during the period likely entered the system through a leak at the potential leak site. If the measuring device was not zeroed out, a spike in the amount of gaseous tracer during the period likely indicates that gaseous tracer entered the system through a leak at the potential leak site. The method 700 may be optionally repeated by discharging a gaseous tracer at a second potential leak location upstream from the first location, and repeating steps 704, 706, and 708.

[0060] FIG. 8 is a flowchart of a method 800 of detecting an air leak in a system configured to coke coal under a negative pressure. The method 800 includes measuring a baseline amount of gaseous tracer at an exhaust stack (process step 802). As previously described in detail with respect to FIG. 7, measuring a baseline amount of gaseous tracer can help account for any amount of gaseous tracer already present in the system. Method 800 further includes discharging a volume of the gaseous tracer adjacent to a potential leak site (process step 804). Similar to method 700, the potential leak site should be located upstream of where the baseline amount of the gaseous tracer was measured. In this case, the potential leak site should be upstream from the exhaust stack. The method 800 continues by monitoring the amount of gaseous tracer at the exhaust stack for a period beginning when the gaseous tracer is discharged at the potential leak site (process step 806). Because the exhaust stack is downstream from the potential leak site, any gaseous tracer that enters the system at the leak site may be detected at the exhaust stack. Thus, the method 800 continues by comparing the baseline amount of gaseous tracer with the amount of gaseous tracer observed during the period to determine if there is a leak at the potential leak site (process step 808). If the measuring device has been zeroed out in step 802 such that the baseline reading of gaseous tracer is zero, any gaseous tracer detected during the period likely entered the system through a leak at the potential leak site. If the measuring device was not zeroed out, a spike in the amount of gaseous tracer during the period likely indicates that gaseous tracer entered the system through a leak at the potential leak site.

[0061] FIG. 9 is a flowchart of a method 900 of detecting an air leak in a system configured to coke coal under a negative pressure. The method 900 includes measuring a baseline amount of gaseous tracer at a downstream location (process step 902). As can be appreciated from the foregoing, a downstream location is any location downstream of the sites to be tested for leaks. And as previously discussed above, measuring a baseline amount of gaseous tracer can help account for any amount of the gaseous tracer already present in the system.

[0062] The method 900 further includes injecting a first amount of a gaseous tracer into the system at a first location, wherein the first location is adjacent to a known leak site or another site that allows air to enter into the system (process step 904). Injecting the gaseous tracer into the system enables an operator to determine how the gaseous

tracer will behave once inside the system. For example, the presence of the gaseous tracer will be monitored at the downstream location so a residence time can be determined for the first amount of gaseous tracer to travel from the first location to the downstream location (process step 906). It may be useful to determine the residence time because it can define the period of time to measure for the gaseous tracer when it has been sprayed on a potential leak site.

[0063] The method 900 continues similarly to method 700. For example, the method 900 includes discharging a second amount of the gaseous tracer adjacent to a potential leak site (process step 908), continuously monitoring the amount of the gaseous tracer at the downstream location beginning when the gaseous tracer is discharged at the potential leak site and lasting for a period equal to the residence time (process step 910), and comparing the baseline amount of the gaseous tracer with the amount of the gaseous tracer observed during the period equal to the residence time to determine if there is a leak at the potential leak site (process step 912). If the measuring device has been zeroed out in step 902 such that the baseline reading of gaseous tracer is zero, any gaseous tracer detected during the period likely entered the system through a leak at the potential leak site. If the measuring device was not zeroed out, a spike in the amount of gaseous tracer during the period likely indicates that gaseous tracer entered the system through a leak at the potential leak site.

[0064] FIG. 10 illustrates a method for detecting a leak and semi-quantitatively estimating the size of the leak. In FIG. 10, method 1000 begins similarly to method 900: measuring a baseline amount of the gaseous tracer at a downstream location (process step 1002). The method 1000 continues by injecting a first known amount of the gaseous tracer into the system at a first location, wherein the first location is adjacent to a known leak site or another site that allows air to enter into the system (process step 1004). As will be described in detail below, injecting a known amount of gaseous tracer can assist in quantitatively defining leaks. To inject a known amount of gaseous tracer, an operator may use a probe configured to dispense a known and constant amount of the gaseous tracer. For example, probe 400 or probe 500, described above with respect to FIGS. 4 and 5, may be utilized to discharge a known amount of gaseous tracer. As described above with respect to method 900, injecting the gaseous tracer into the system enables an operator to determine how the gaseous tracer will behave once inside the system. For example, the presence of the gaseous tracer will be monitored

at the downstream location so a residence time can be determined for the first amount of gaseous tracer to travel from the first location to the downstream location (process step 706).

[0065] The method 1000 continues by discharging a second known amount of gaseous tracer adjacent to a potential leak site (process step 1008), continuously monitoring the amount of gaseous tracer beginning when the gaseous tracer is discharged at the potential leak site and lasting for at least a period equal to the residence time (process step 1010), and comparing the baseline amount of the gaseous tracer with the amount of the gaseous tracer observed during the period equal to the residence time to determine (i) if there is a leak at the potential leak site, and (ii) the size of the leak (process step 1012). With respect to determining whether there is a leak, method 1000 operates in a generally similar fashion as the methods described above: if the measuring device has been zeroed out in step 1002 such that the baseline reading of gaseous tracer is zero, any gaseous tracer detected during the period likely entered the system through a leak at the potential leak site, and if the measuring device was not zeroed out, a spike in the amount of gaseous tracer during the period likely indicates that the gaseous tracer entered the system through a leak at the potential leak site. However, because the amount of gaseous tracer injected in step 1004 and discharged in step 1008 are known, the relative size of the leak can also be determined. For example, the amount discharged in steps 1004 and 1008 can be equal. Since the first known amount of the gaseous tracer is injected into the system, the amount measured at the downstream location following this injection can represent an expected upper limit on the amount of gaseous tracer that could be observed in step 1010. Thus, the amount of the gaseous tracer observed in step 1010 can be compared to the amount of the gaseous tracer observed following step 1004 to get a semi-quantitative estimate of the size of the leak.

[0066] FIG. 11 illustrates one exemplary method for determining which of two potential leaks is larger. In FIG. 11, method 1100 begins with measuring a baseline amount of a gaseous tracer at a downstream location (process step 1102), discharging a first known amount of the gaseous tracer adjacent to a first leak site (process step 1104), and continuously monitoring a first amount of the gaseous tracer for a first period beginning when the gaseous tracer is discharged adjacent to the first potential leak site (process step 1106). The method 1100 continues by comparing the baseline amount

of the gaseous tracer with the first amount of gaseous tracer observed during the first period to determine if there is a first leak at the first potential leak site (process step 1108). If a spike in the amount of gaseous tracer above the baseline amount is observed during the first period, there is likely a leak at the first potential leak site. The method 1100 further includes discharging a second known amount of gaseous tracer adjacent to a second potential leak site (process step 1110). In order to semi-quantitatively measure the relative size of a potential leak, the second known amount of gaseous tracer should be approximately equal and/or equal to the first known amount. To do this, an operator may use a probe configured to dispense a known and constant amount of gaseous tracer. For example, probe 400 or probe 500, described above with respect to FIGS. 4 and 5, may be utilized to discharge a known and constant amount of gaseous tracer. The method 1100 next includes continuously monitoring the second amount of gaseous tracer at the downstream location for a second period beginning when the gaseous tracer is discharged at the second potential leak site (process step 1112). The second period should be approximately equal and/or equal to the first period. Method 1100 continues by comparing the baseline amount of the gaseous tracer with the second amount of the gaseous tracer to determine if there is a second leak at the second potential leak site (process step 1114). If a spike in the amount of gaseous tracer above the baseline amount is observed during the second period, there is likely a leak at the second potential leak site.

[0067] Method 1100 continues by determining whether the first leak or the second leak is larger. To do so, the first amount of the gaseous tracer observed during the first period is compared with the second amount of the gaseous tracer observed during the second period (process step 1116). Since the first known amount and second known amount of gaseous tracer discharged adjacent to the first and second potential leak sites are the same amount, the amount of gaseous tracer observed during the first and second period can indicate whether the first or second leak is larger. For example, if more gaseous tracer is detected during the first period than during the second period, the first leak is likely larger than the second leak. Likewise, if more gaseous tracer is detected during the second period than during the first period, the second leak is likely larger than the first leak. This information can be useful, for example, in prioritizing which leak to fix first.

[0068] FIG. 12 illustrates another exemplary method for detecting leaks and for identifying which of two potential leaks are larger. Method 1200 in FIG. 12 is similar to method 1100, except that it includes determining a residence time to precisely define the period to monitor for the gaseous tracer following application of the gaseous tracer to a potential leak site. Method 1200 begins by measuring a baseline amount of gaseous tracer at a downstream location, which comprises a first measurement (process step 1202). The method 1200 continues by injecting a first known volume of the gaseous tracer into the system at a first location that is adjacent to a known leak site or another site that allows air to enter into the system (process step 1204). From this, a residence time for the first known amount of the gaseous tracer to travel from the first location to the downstream location is determined (process step 1206). Method 1200 continues by discharging a second known amount of the gaseous tracer adjacent to a first leak site (process step 1208), and continuously measuring a second amount of the gaseous tracer for a period equal to the residence time, which comprises a second measurement (process step 1210). The method 1200 continues by comparing the first measurement with the second measurement to determine if there is a first leak at the first potential leak site (process step 1212). If a spike in the amount of gaseous tracer above the baseline amount is observed during the first measurement, there is likely a leak at the first potential leak site.

[0069] Similar to FIG. 11, the method 1200 further includes discharging a third known amount of gaseous tracer adjacent to a second potential leak site (process step 1214). In order to semi-quantitatively measure the relative size of a potential leak, the second known amount of gaseous tracer should be approximately equal and/or equal to the first known amount. To do this, an operator may use a probe configured to dispense a known and constant amount of gaseous tracer. For example, probe 400 or probe 500, described above with respect to FIGS. 4 and 5, may be utilized to inject a known and constant amount of gaseous tracer. The method 1200 next includes continuously measuring the third amount of gaseous tracer at the downstream location for at least a period equal to the residence time, which comprises a third measurement (process step 1216). Method 1200 continues by comparing the first measurement with the third measurement to determine if there is a second leak at the second potential leak site (process step 1218). If a spike in the amount of gaseous tracer above the

baseline amount is observed during the second period, there is likely a leak at the second potential leak site.

[0070] Method 1200 continues by determining whether the first leak or the second leak is larger. To do so, the third measurement is compared with the second measurement (process step 1220). Since the first known amount and second known amount of gaseous tracer discharged adjacent to the first and second potential leak sites are the same amount, the relative amount of gaseous tracer in the second and third measurements can indicate whether the first or second leak is larger. For example, if more gaseous tracer is detected during the second measurement, the first leak is likely larger than the second leak. Likewise, if more gaseous tracer is detected during the third measurement, the second leak is likely larger than the first leak. This information can be useful, for example, in prioritizing which leak to fix first.

[0071] FIG. 13 is an exemplary method of quantitatively defining and comparing leaks. In FIG. 13, method 1300 includes injecting a first known amount of a gaseous tracer into the system at a first location adjacent to a known leak site or another site that allows air to enter into the system (process step 1302). In some embodiments, the first location should allow a substantial amount of the gaseous tracer to enter into the system. For example, in one embodiment, the first known amount of the gaseous tracer is discharged directly into the system. Method 1300 continues by measuring a first amount of the gaseous tracer at a location downstream of the first location (process step 1304). Next, a first volume versus time graph of the first amount of the gaseous tracer is generated (process step 1306). For example, continuous measurements taken with a mass spectrometer may be plotted on a volume versus time graph. To define the period to graph, a residence time for the gaseous tracer to move through the system may optionally be determined as described in detail above. However, in some embodiments, a period may equal 240 seconds or less, 120 seconds or less, 90 seconds or less, 60 seconds or less, 45 seconds or less, 30 seconds or less, and/or 15 seconds or less. Resultant graphs may include, for example, a slope, one or more inflection points, and a magnitude (e.g., area under the curve). The slope and magnitude of the graph may constitute quantitative parameters of the volume of the gaseous tracer detected. For example, a larger magnitude (e.g., area under the curve) indicates more gaseous tracer entered the system. The inflection points and/or the number of spikes in concentration may, for example, indicate whether the gaseous

tracer entered the system at a single location, or whether it entered at one or more locations.

[0072] Method 1300 continues by discharging a second known amount of the gaseous tracer adjacent to a first potential leak site (process step 1308). The second amount of the gaseous tracer should be approximately equal to the first known amount. Method 1300 further includes measuring a second amount of the gaseous tracer at the location downstream of the first location, wherein the downstream location is also downstream of the second potential leak site (process step 1310), and generating a second volume versus time graph of the second amount of the gaseous tracer, wherein the graph includes a slope, inflection points, and a magnitude (process step 1312). This can be done in a similar fashion as described above with respect to step 1306.

[0073] The first volume versus time graph and the second volume versus time graph may be compared to determine (i) if there is a leak at the potential leak site, and (ii) the size of the leak. To determine whether there is a leak, the second volume versus time graph can be analyzed. If there is a spike in the amount of gaseous tracer observed, there is likely a leak. To determine the size of the leak, the first and second volume versus time graphs may be compared. Since the first volume versus time graph resulted from injecting the gaseous tracer into the system, it quantifies the behavior of the gaseous tracer if approximately all of the gaseous tracer entered the system. Thus, the second volume versus time graph can be compared against the first volume versus time graph to quantitatively determine certain characteristics of the leak. For example, if the magnitude under the curve of the second graph approaches the magnitude under the curve of the first graph, the leak is relatively large (e.g., more gaseous tracer was able to enter the system through the leak). If the magnitude under the curve of the second graph is much smaller than the first graph, the leak is relatively small (e.g., less gaseous tracer was able to enter the system through the leak). Likewise, the distance between inflection points can indicate whether the gaseous tracer entered through a single leak or through two or more leaks. If there are multiple inflection points spaced apart from each other, the gaseous tracer may have entered through multiple leaks, with each inflection point indicating a separate leak. In some embodiments, the data collected from one or more of the tests described herein can be analyzed using an algorithm or other computational modeling software. In some embodiments, the data is analyzed to determine an estimated leak rate (e.g., in lbs/hr and/or O₂%). Such

modeling may also predict the reduction of the leak rate following repair of one or more specific leaks and may help a user prioritize which leak(s) to repair first. Moreover, although method 1300 is described above with respect to measuring a volume of the gaseous tracer and generating a volume versus time graph, one skilled in the art will recognize that other measurements corresponding to an amount of the gaseous tracer (e.g., mass, moles, etc.) could be utilized.

[0074] FIG. 14 is an exemplary method in accordance with the present technology that enables a user to test for leaks across a first region of a coking system, and, if a leak is found, test smaller regions within the first region to determine where the leak is. In FIG. 14, method 1400 includes spraying a first external facing region of a system for coking coal with a gaseous tracer (process step 1402). The first external facing region of the system may be any region of the system that may be susceptible to leaks. The size of the first region may be variable: for example, in some embodiments, the first region may be between about 5 square feet and about 50 square feet. The method continues by measuring the gaseous tracer in the system at a location downstream of the first external facing region (process step 1404). If a spike in the gaseous tracer is detected, there is a leak within the first external facing region. Accordingly, to determine a more precise location of the leak within the first region, a second external facing region positioned within the first external facing region and having a smaller surface area than the first external facing region may be sprayed with gaseous tracer (process step 1406). The gaseous tracer will be measured for at a location downstream of the second external facing region (process step 1408). If gaseous tracer is detected, there is likely a leak within the second region. If no gaseous tracer is detected, there is likely no leak in the second region. Steps 1406 and 1408 may be repeated in other sub-regions of the first external facing region to determine if there are other leaks in other regions of the first external facing region.

[0075] FIG. 15 illustrates an exemplary method of combining a gaseous tracer leak detection test with a visually based smoke or colored gas test. In FIG. 15, method 1500 begins by spraying an external facing region of a system for coking coal with a gaseous tracer (process step 1502), and measuring the amount of the gaseous tracer in the system at a location downstream of the first external facing region (process step 1504). If a spike in the amount of gaseous tracer is detected, there is likely a leak within the external facing region. To better determine where the leak is within the first external

facing region, a device configured to dispense smoke or colored gas may be dispensed adjacent to the external facing region (process step 1506). An example of such device is a smoke bomb. However, any device configured to dispense smoke and/or colored gas may be suitable. After the device has dispensed the smoke or colored gas, a user will observe the smoke or colored gas to detect a sub-region of the external facing region that has one or more cracks (process step 1508). The cracks may be detected, for example, by observing smoke or colored gas being sucked into the system in a sub-region, thereby indicating there is a leak in the sub-region.

[0076] FIG. 16 illustrates another exemplary method of detecting a leak between a high-pressure system and a low-pressure system. In FIG. 16, method 1600 includes injecting a gaseous tracer into a high-pressure system at a first location adjacent to a low-pressure system (process step 1602). For example, the gaseous tracer may be injected adjacent to a structure configured to at least partially divide the high-pressure system and the low-pressure system. In some embodiments, the high-pressure system and low-pressure system are designed to be fluidly isolated. For example, the high-pressure system and low-pressure system might be in complete fluid isolation, or the high-pressure system and low-pressure system might be designed such that they are not uncontrollably fluidly connected (e.g., a fluid connection includes a controllable damper to fluidly isolate the high-pressure system and the low-pressure system). Once the gaseous tracer has been injected in the high-pressure system, the amount of gaseous tracer is measured at a second location within (or downstream from) the low-pressure system (process step 1604). Because the high-pressure system and low-pressure system are designed to be fluidly isolated, detecting a spike in the amount of gaseous tracer in the low-pressure system indicates there is a leak between the high-pressure system and low-pressure system. In some embodiments, the high-pressure system is a byproduct coking system, and the low-pressure system is external to the byproduct coking system. In some embodiments, the high-pressure system is a first aspect of a byproduct coking system (e.g., an oven), and the low-pressure system is a second aspect of the byproduct coking system (e.g., a flue chamber surrounding the oven). In yet other embodiments, the high-pressure system is the external environment and the low-pressure system is a heat recovery coking system.

[0077] FIG. 17 illustrates another exemplary method of detecting a leak between a high-pressure system and a low-pressure system. In FIG. 17, method 1700 includes

injecting a gaseous tracer into a high-pressure system at a first location adjacent to a low-pressure system (process step 1702), and measuring the amount of gaseous tracer at a second location inside the low-pressure system (process step 1704). The high-pressure system and/or the low-pressure system can be one or more regions within a byproduct coke plant (e.g., ovens, flue chambers, etc.). In some embodiments, gas within the high-pressure system may eventually reach the low-pressure system through one or more connecting ducts, regardless of whether a leak between the high-pressure system and low-pressure system exists. Thus, in some embodiments, gas or air in the high-pressure system may enter the low-pressure system, even if there is no leak between the high-pressure and low-pressure systems. Accordingly, in some embodiments, a single spike in the amount of gaseous tracer measured does not necessarily indicate that there is a leak. Instead, detecting multiple, temporally spaced apart spikes (e.g., a first spike and a second spike) in the amount of gaseous tracer at the second location indicate the potential presence of a leak between the high-pressure system and the low-pressure system (process step 1706). The first spike may occur within a first period of time beginning when the gaseous tracer is injected (e.g., less than 5 seconds, less than 10 seconds, less than 15 seconds, less than 20 seconds etc.), and the second spike may occur during a second period of time beginning when the gaseous tracer is injected (e.g., more than 5 seconds, more than 10 seconds, more than 15 seconds, more than 20 seconds, etc.). The first spike may represent gaseous tracer entering the low-pressure system through a leak, and the second spike may represent gaseous tracer entering the low-pressure system through the one or more connection ducts. In some embodiments, the high-pressure system is a first aspect of a byproduct coking system, and the low-pressure system is a second aspect of a byproduct coking system.

[0078] Other embodiments of the present technology integrate aspects of the gaseous tracer tests described herein with a coke plant monitoring system. For example, the coke plants described herein can include various sensors (e.g., oxygen sensors) that continuously or at least semi-continuously detect the presence of a target substance or molecule (e.g., oxygen). If an unexplained change in concentration of the target substance or molecule is sensed by the sensor (e.g., if the concentration of measured oxygen unexpectedly increases), the monitoring system can send an alert to a user. The alert can state that an abnormality was sensed, and/or can include more

detailed information such as a suspected location of a problem (e.g., leak) causing the abnormality. The alert can direct the user to said location to perform a gaseous tracer test as described herein to more accurately identify the leak, identify the precise location of the leak, and/or semi-quantitatively analyze a size of the leak. In some embodiments, the monitoring system may also include a gaseous tracer detector (e.g., a Helium detector, etc.) such that a user does not need to deploy a gaseous tracer detector after receiving the alert and before conducting the gaseous tracer test.

Examples

[0079] The following examples are provided to further illustrate embodiments of the present technology and are not to be interpreted as limiting the scope of the present technology. To the extent that certain embodiments or features thereof are mentioned, it is merely for purposes of illustration and, unless otherwise specified, is not intended to limit the present technology. It will be understood that many variations can be made in the procedures herein described while still remaining within the bounds of the present technology. Such variations are intended to be included within the scope of the presently disclosed technology.

Example 1

[0080] A gaseous tracer test representative of some embodiments of the present technology was performed to detect leaks in or around a heat recovery steam generator in a heat recovery coking system. A helium detector was placed downstream from the heat recovery steam generator adjacent the main stack at the outlet of the induced draft fans, although in other examples other locations downstream from the tested surface can be used, as described in detail above. The detector was positioned to measure helium concentration inside of the heat recovery coking system. Before testing for leaks, a known volume of helium was injected into an open oven uptake while the detector was recording helium concentration. The time between the injection of helium into the open oven uptake and the detection of the helium at the downstream detector defined a residence time for the helium. Once the residence time was determined, and with the helium detector continuously monitoring helium levels, helium was discharged using a probe generally similar to probe 400. More specifically, the helium was sprayed on various external facing surfaces of the heat recovery steam generators. As discussed above, the present technology enables a user to sequentially test multiple

surfaces for leaks. Accordingly, the probe was used to spray various surfaces of the heat recovery steam generator while the helium detector was continuously recording the concentration of helium within the system. The results of the tests are illustrated in FIG. 18. The x-axis represents time (in seconds), and the y-axis represents the concentration of helium detected by the mass spectrometer (e.g., the leak rate LR). As illustrated in FIG. 18, the helium detector measured two primary spikes in helium concentration (labeled A and B, respectively). Based on the residence time that it takes for the helium to flow from the leak to the helium detector, the location of a leak associated with the first spike can be calculated. For example, the first spike A was measured approximately 30 seconds after spraying a first external surface of the heat recovery steam generator, and the second spike B was measured approximately 30 seconds after spraying a second external surface of the heat recovery steam generator. Accordingly, the graph indicates there is a first leak at the first external surface and a second leak at the second external surface. In the present example, the first leak was associated with a cross-over portion of the heat recovery steam generator (e.g., a cross-over duct), and the second leak was associated with an elbow of the heat recovery steam generator. The area under the first spike A and the area of under the second spike B can be calculated to semi-quantitatively assess the magnitude of the leak. For example, assuming other variables are approximately equal, such as the amount of helium discharged at each test location, if the area under the curve at the first spike A is greater than the area under the curve at the second spike B, the leak indicated by the first spike A is likely larger (i.e., allowing greater airflow into the system) than the leak indicated by the second spike B.

Example 2

[0081] A gaseous tracer test representative of some embodiments of the present technology was performed to detect leaks in or around a heat recovery steam generator in a heat recovery coking system. A helium detector was placed downstream from the heat recovery steam generator adjacent the main stack at the outlet of the induced draft fans, although in other examples other locations downstream from the tested surface can be used, as described in detail above. The detector was positioned to measure helium concentration inside of the heat recovery coking system. Before testing for leaks, a known volume of helium was injected into an open oven uptake while the detector was recording helium concentration. The time between the injection of helium

into the open oven uptake and the detection of the helium at the downstream detector defined a residence time for the helium. Once the residence time was determined, and with the helium detector continuously monitoring helium levels, helium was discharged using a probe generally similar to probe 400. More specifically, the helium was sprayed on various external facing surfaces of the ovens that are designed to be fluidly isolated from an interior of the system. The results of the tests are illustrated in FIG. 19. The x-axis represents time (in seconds), and the y-axis represents the concentration of helium detected by the helium detector. The dashed line represents the helium concentration, and the solid gray shaded area beneath the dashed line represents the detected helium minus the control amount of helium (e.g., an ambient amount of helium not introduced via a test). Accordingly, spikes in the solid gray shaded area reflect helium entering the system in an uncontrolled manner, such as via a leak. Each measurement A–H represents a different tested structure (e.g., a first oven door, a first oven side wall, a second oven door, a second oven side wall, etc.). Table 1 reports the numerical results of the test:

Surface	time	LR(Atm.cc/s)
A	9:50	3.40E-07
B	9:52	1.60E-06
C	9:53	4.70E-07
D	10:05	4.70E-07
E	10:08	3.60E-07
F	10:14	1.00E-06
G	10:15	4.50E-07
H	10:17	4.10E-07

[0082] The concentration of detected helium spiked after spraying surfaces B and F. For example, the concentration of detected helium spiked from around 3.40E^{-7} Atm.cc/s after spraying surface A to about 1.6E^{-6} Atm.cc/s after spraying surface B. This indicates that more helium entered the system after spraying surface B than after spraying surface A. Likewise, the concentration of detected helium spiked from around 3.6E^{-7} Atm.cc/s after spraying surface E to about 1.0E^{-6} Atm.cc/s after spraying surface F. Accordingly, this indicates that more helium entered the system after spraying

surface F than after spraying surface E. Any of the above values can be compared to determine which surfaces are allowing the most air to enter the system.

[0083] As can be appreciated from the foregoing disclosure, the representative systems and methods described above may be combined in various manners to achieve desired results. Accordingly, this disclosure is not intended to be exhaustive or to limit the present technology to the precise forms disclosed herein. Although specific embodiments are disclosed herein for illustrative purposes, various equivalent modifications are possible without deviating from the present technology, as those of ordinary skill in the art will recognize. In some cases, well-known structures and functions have not been shown or described in detail to avoid unnecessarily obscuring the description of the embodiments of the present technology. Although steps of methods may be presented herein in a particular order, alternative embodiments may perform the steps in a different order. Similarly, certain aspects of the present technology disclosed in the context of particular embodiments can be combined or eliminated in other embodiments. Furthermore, while advantages associated with certain embodiments of the present technology may have been disclosed in the context of those embodiments, other embodiments of the present technology may have been disclosed in the context of those embodiments, other embodiments can also exhibit such advantages, and not all embodiments need necessarily exhibit such advantages or other advantages disclosed herein to fall within the scope of the technology. Accordingly, the disclosure and associated technology can encompass other embodiments not expressly shown or described herein.

[0084] Throughout this disclosure, the singular terms “a,” “an,” and “the” include plural referents unless the context clearly indicates otherwise. Similarly, unless the word “or” is expressly limited to mean only a single item exclusive from the other items in reference to a list of two or more items, then the use of “or” in such a list is to be interpreted as including (a) any single item in the list, (b) all of the items in the list, or (c) any combination of items in the list. Additionally, the term “comprising” is used throughout to mean including at least the recited feature(s) such that any greater number of the same feature and/or additional types of other features are not precluded. Reference herein to “one embodiment,” “an embodiment,” or similar formulations means that a particular feature, structure, operation, or characteristic described in connection with the embodiment can be included in at least one embodiment of the present

technology. Thus, the appearances of such phrases or formulations herein are not necessarily all referring to the same embodiment. Furthermore, various particular features, structures, operations, or characteristics may be combined in any suitable manner in one or more embodiments.

CLAIMS

I/We claim:

1. A method of detecting a leak in a system for coking coal, the method comprising:
 - operating a low-pressure system within a structure comprising insulation, and in a negative pressure and high temperature environment of at least 1000 degrees Celsius, the low-pressure system being configured to produce coke and comprising a passageway including at least one oven having an oven chamber, at least one sole flue chamber fluidically coupled to the oven chamber, a tunnel fluidically coupled to the sole flue chamber, and a draft fan fluidically coupled to tunnel and configured to control air pressure within the oven chamber;
 - discharging a gaseous tracer into a high-pressure system adjacent to the structure to enable the gaseous tracer to flow through the passageway, wherein flow through the passageway is characterized by a Reynolds number of at least 4,000 and a residence time, the Reynolds number and the residence time being dependent on operation of the draft fan and the passageway of the low-pressure system, the structure being configured to fluidly isolate the high-pressure system and the low-pressure system; and
 - after discharging the gaseous tracer, measuring an amount of the gaseous tracer at a location within and/or downstream from the low-pressure system downstream of at least one of the oven chamber, sole flue chamber, or tunnel, wherein a measured amount of the gaseous tracer above a predetermined amount at the location within the low-pressure system indicates there is a leak in the structure.
2. The method of claim 1, wherein the system for coking coal is a heat recovery coke plant, a non-heat recovery coke plant, or a byproduct coke plant.
3. The method of claim 1, further comprising:
 - measuring a baseline amount of the gaseous tracer before discharging the gaseous tracer adjacent to the structure; and

comparing the baseline amount of the gaseous tracer with the gaseous tracer measured after discharging the gaseous tracer adjacent the structure to determine if there is a leak.

4. The method of claim 3, wherein measuring the baseline amount of gaseous tracer further comprises zeroing a reading on a measuring device.

5. The method of claim 1, wherein measuring the amount of gaseous tracer at the location comprises continuously measuring the amount of gaseous tracer for a period.

6. The method of claim 1, wherein the gaseous tracer mixes with other gases in the system for coking coal, and wherein the flow of the gaseous tracer and other gases is turbulent in at least one region of the system between the structure and the location.

7. The method of claim 1, wherein discharging the gaseous tracer adjacent to the structure comprises discharging the gaseous tracer within two inches of the structure.

8. The method of claim 1, wherein discharging the gaseous tracer adjacent to the structure comprises spraying the gaseous tracer across a first external facing surface of the system for coking coal.

9. The method of claim 8, wherein discharging the gaseous tracer comprises discharging a first amount of the gaseous tracer adjacent to the structure, the method further comprising discharging a second amount of the gaseous tracer adjacent to the structure if a leak is detected at the structure, wherein the second amount of the gaseous tracer is sprayed on a second external facing surface area of the system positioned within and smaller than a first external facing surface area of the first external facing surface.

10. The method of claim 1, wherein the gaseous tracer is a compound (a) that is not otherwise present in the system and (b) that is detectable at the location.

11. The method of claim 1, wherein the gaseous tracer is a noble gas.

12. The method of claim 1, wherein the gaseous tracer is helium.
13. The method of claim 1, wherein the structure includes insulation.
14. The method of claim 1, wherein the steps of discharging the gaseous tracer and measuring the amount of the gaseous tracer are performed without shutting off operation of the system for coking coal.
15. A method of detecting an leak in a system for coking coal, the method comprising:
operating a low-pressure system within a structure comprising insulation, and in a negative pressure and high temperature environment of at least 1000 degrees Celsius, the low-pressure system being configured to produce coke and comprising a passageway including at least one oven having an oven chamber, at least one sole flue chamber fluidically coupled to the oven chamber, a tunnel fluidically coupled to the sole flue chamber, and a draft fan fluidically coupled to tunnel and configured to control air pressure within the oven chamber;
injecting a first known amount of gaseous tracer into the system at a first location to enable the gaseous tracer to flow through the passageway, wherein flow through the passageway is characterized by a Reynolds number of at least 4,000 and a residence time, the Reynolds number and the residence time being dependent on operation of the draft fan and the passageway of the low-pressure system, wherein the first location is adjacent to a known leak site or another site that allows air to enter into the low-pressure system;
measuring a first test amount of the gaseous tracer at a location downstream of the first location and at least one of the oven chamber, sole flue chamber, or tunnel;
generating a first volume versus time graph of the first test amount of the gaseous tracer;
discharging a second known amount of the gaseous tracer adjacent to a first potential leak site, wherein the second known amount is equal to the first known amount;

measuring a second test amount of the gaseous tracer at the location downstream of the first location, wherein the location downstream of the first location is also downstream of the first potential leak site;
generating a second volume versus time graph of the second test amount of the gaseous tracer;
and
comparing the first and second graphs to determine (i) if there is a leak at the first potential leak site, and/or (ii) the size of the leak.

16. The method of claim 15, wherein:

the first volume versus time graph has a first slope, one or more first inflection points, and a first magnitude; and

the second volume versus time graph has a second slope, one or more second inflection points, and a second magnitude.

17. The method of claim 16, wherein the size of the leak is determined by comparing the first slope with the second slope and/or by comparing the first magnitude with the second magnitude.

18. The method of claim 16 wherein the first magnitude corresponds to a first area under the curve and the second magnitude corresponds to a second area under the curve.

19. The method of claim 16, further comprising comparing the distance between the one or more first inflection points with the distance between the one or more second inflection points to determine whether there is one leak or multiple leaks.

20. The method of claim 15, wherein injecting the first amount of the gaseous tracer into the system and discharging the second amount of the gaseous tracer adjacent to the first potential leak site comprises using a gaseous tracer spray probe, the probe including:

a regulator;

a known volume container carrying a known volume of the gaseous tracer; and

a valve configured to dispense a known volume of the gaseous tracer equal to the first and second known amounts of the gaseous tracer.

21. The method of claim 15, wherein the system comprises a plurality of coke ovens, a plurality of heat recovery steam generators, and a common tunnel fluidly coupled to the plurality of coke ovens and the plurality of heat recovery steam generators.

22. A method of detecting an air leak in a system for coking coal, the method comprising: operating a low-pressure system within a structure comprising insulation, and in a negative pressure and high temperature environment of at least 1000 degrees Celsius, the low-pressure system being configured to produce coke and comprising a passageway including at least one oven having an oven chamber, at least one sole flue chamber fluidically coupled to the oven chamber, a tunnel fluidically coupled to the sole flue chamber, and a draft fan fluidically coupled to tunnel and configured to control air pressure within the oven chamber;

measuring a baseline amount of a gaseous tracer at a first location of a high-pressure system to enable the gaseous tracer to flow through the passageway, wherein flow through the passageway is characterized by a Reynolds number of at least 4,000 and a residence time, the Reynolds number and the residence time being dependent on operation of the draft fan and the passageway of the low-pressure system;

injecting a first amount of the gaseous tracer into the low-pressure system at a second location upstream of the first location, wherein the second location is adjacent to a known leak site or another site that allows air to enter into the low-pressure system;

determining a residence time for the first amount of the gaseous tracer to travel from the second location to the first location;

discharging a second amount of the gaseous tracer adjacent to a first potential leak site upstream from the first location;

measuring an amount of the gaseous tracer at the first location beginning when the gaseous tracer is discharged at the first potential leak site for a first period approximately equal to or longer than the residence time; and

comparing the baseline amount of the gaseous tracer with the amount of the gaseous tracer measured during the first period to determine if there is a leak at the first potential leak site.

23. The method of claim 22, further comprising:
discharging a third amount of the gaseous tracer adjacent to a second potential leak site;
measuring an amount of the gaseous tracer at the first location beginning when the gaseous tracer is discharged at the second potential leak site and lasting for a second period approximately equal to or longer than the residence time; and
comparing the baseline amount of the gaseous tracer with the amount of the gaseous tracer observed during the second period to determine if there is a leak at the second potential leak site.

24. The method of claim 23, wherein the first amount of the gaseous tracer, the second amount of the gaseous tracer, and the third amount of the gaseous tracer are equal.

25. The method of claim 24, further comprising, when there is a first leak at the first potential leak site and a second leak at the second potential leak, comparing the amount of the gaseous tracer measured during the first period and the second period to determine whether the first leak or second leak is larger.

26. The method of claim 24, further comprising, when there is a first leak at the first potential leak site and a second leak at the second potential leak site, determining which leak to repair first by comparing the amount of the gaseous tracer measured during the first period and the amount of the gaseous tracer measured during the second period.

27. The method of claim 24, wherein comparing the amount of the gaseous tracer measured during the first and second periods comprises:
generating a first amount versus time graph of the gaseous tracer during the first period and a second amount versus time graph of the gaseous tracer during the second period, wherein:

the first amount is a first volume or a first mass,
the second amount is a second volume or a second mass,
the first amount versus time graph has a first area under the curve, and
the second amount versus time graph has a second area under the curve; and
comparing the first area under the curve and the second area under the curve.

28. The method of claim 27, wherein the first amount versus time graph further comprises a first shape, and wherein the second amount versus time graph further comprises a second shape, and wherein comparing the amount of the gaseous tracer further comprises comparing the first shape and the second shape.

29. The method of claim 22, wherein the residence time is 120 seconds or less.

30. The method of claim 22, wherein the system comprises a plurality of coke ovens, a sole flue chamber, a plurality of air ducts fluidly connecting the sole flue chamber and the plurality of coke ovens, a plurality of heat recovery steam generators, a common tunnel, and/or a plurality of uptake ducts fluidly coupling the plurality of coke ovens and/or the plurality of heat recovery steam generators.

31. A method of detecting an air leak in a system for coking coal under a negative pressure, the method comprising:

operating a low-pressure system within a structure comprising insulation, and in a negative pressure and high temperature environment of at least 1000 degrees Celsius, the low-pressure system being configured to produce coke and comprising a passageway including at least one oven having an oven chamber, at least one sole flue chamber fluidically coupled to the oven chamber, a tunnel fluidically coupled to the sole flue chamber, and a draft fan fluidically coupled to tunnel and configured to control air pressure within the oven chamber;

spraying an external facing region of the low-pressure system with a gaseous tracer; measuring an amount of the gaseous tracer in the system for coking coal at a location

downstream from the external facing region to enable the gaseous tracer to flow

through the passageway, wherein flow through the passageway is characterized by a Reynolds number of at least 4,000 and a residence time, the Reynolds number and the residence time being dependent on operation of the draft fan and the passageway of the low-pressure system, wherein a measured amount of the gaseous tracer above a predetermined amount indicates there is one or more leaks in the external facing region; discharging a device configured to dispense smoke or colored gas adjacent to the external facing region of the system; and observing the discharged smoke or colored gas to detect a sub-region of the external facing region having the one or more leaks.

32. The method of claim 31, wherein the device is a smoke generator or a smoke bomb.

33. A method of detecting an air leak between a high-pressure system and a low-pressure system, wherein the high-pressure system and the low-pressure system are designed to be fluidly isolated, the method comprising:

operating the low-pressure system within a structure comprising insulation, and in a negative pressure and high temperature environment of at least 1000 degrees Celsius, the low-pressure system being configured to produce coke and comprising a passageway including at least one oven having an oven chamber, at least one sole flue chamber fluidically coupled to the oven chamber, a tunnel fluidically coupled to the sole flue chamber, and a draft fan fluidically coupled to tunnel and configured to control air pressure within the oven chamber;

injecting a gaseous tracer into the high-pressure system at a first location adjacent the low-pressure system to enable the gaseous tracer to flow through the passageway, wherein flow through the passageway is characterized by a Reynolds number of at least 4,000 and a residence time, the Reynolds number and the residence time being dependent on operation of the draft fan and the passageway of the low-pressure system; and

measuring a concentration of the gaseous tracer at a second location after injecting the gaseous tracer into the high-pressure system, wherein the second location is inside the low-pressure system; and

wherein detecting the gaseous tracer in the low-pressure system after injecting the gaseous tracer into the high-pressure system indicates there is a leak between the high-pressure system and the low-pressure system.

34. The method of claim 33, further comprising:

measuring a baseline concentration of the gaseous tracer in the low-pressure system before discharging the gaseous tracer into the high-pressure system; and

comparing the baseline concentration of the gaseous tracer with a test concentration of the gaseous tracer measured in the low-pressure system after discharging the gaseous tracer into the high-pressure system to determine if there is a leak.

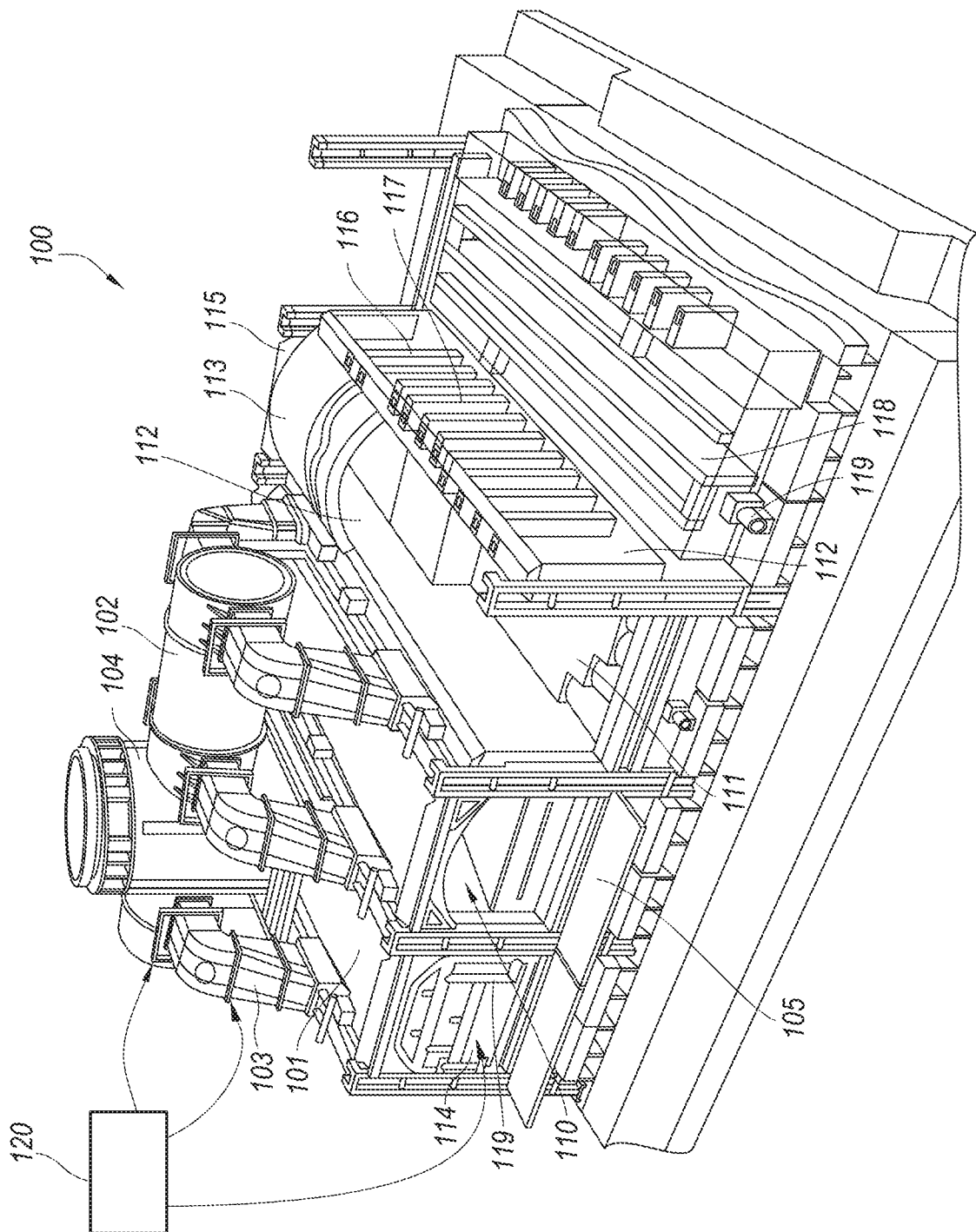
35. The method of claim 33, further comprising:

generating a volume versus time graph of the concentration of the measured gaseous tracer;
and

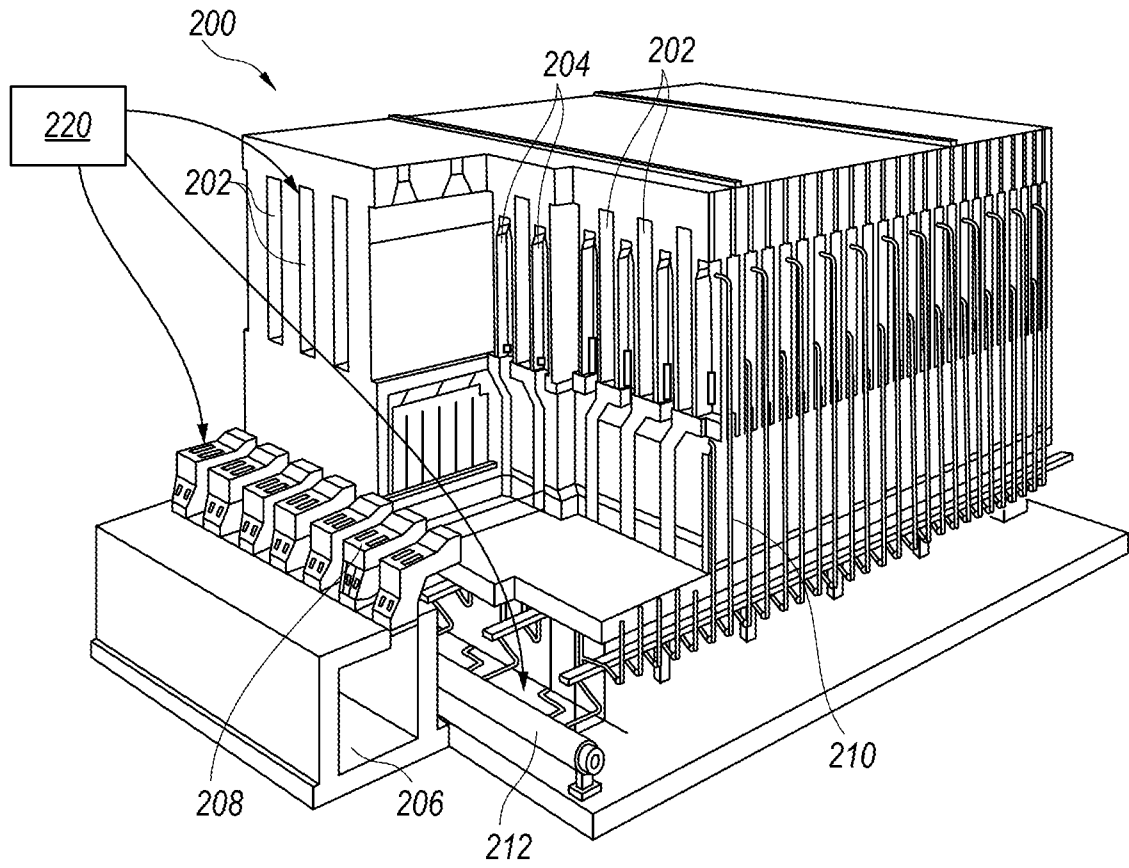
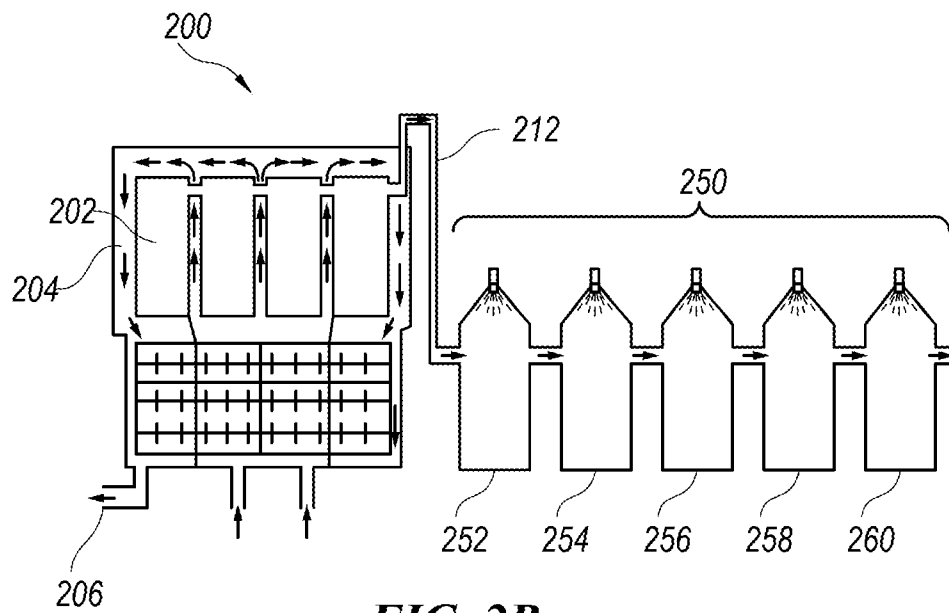
at least semi-quantitatively determining a size of the leak.

36. The method of claim 33, wherein at least one of the high-pressure system and the low-pressure system is a region within a coke plant, and wherein the steps of injecting and measuring are performed without shutting off operation of the coke plant.

1/18

**FIG. 1**

2/18

**FIG. 2A****FIG. 2B**

3/18

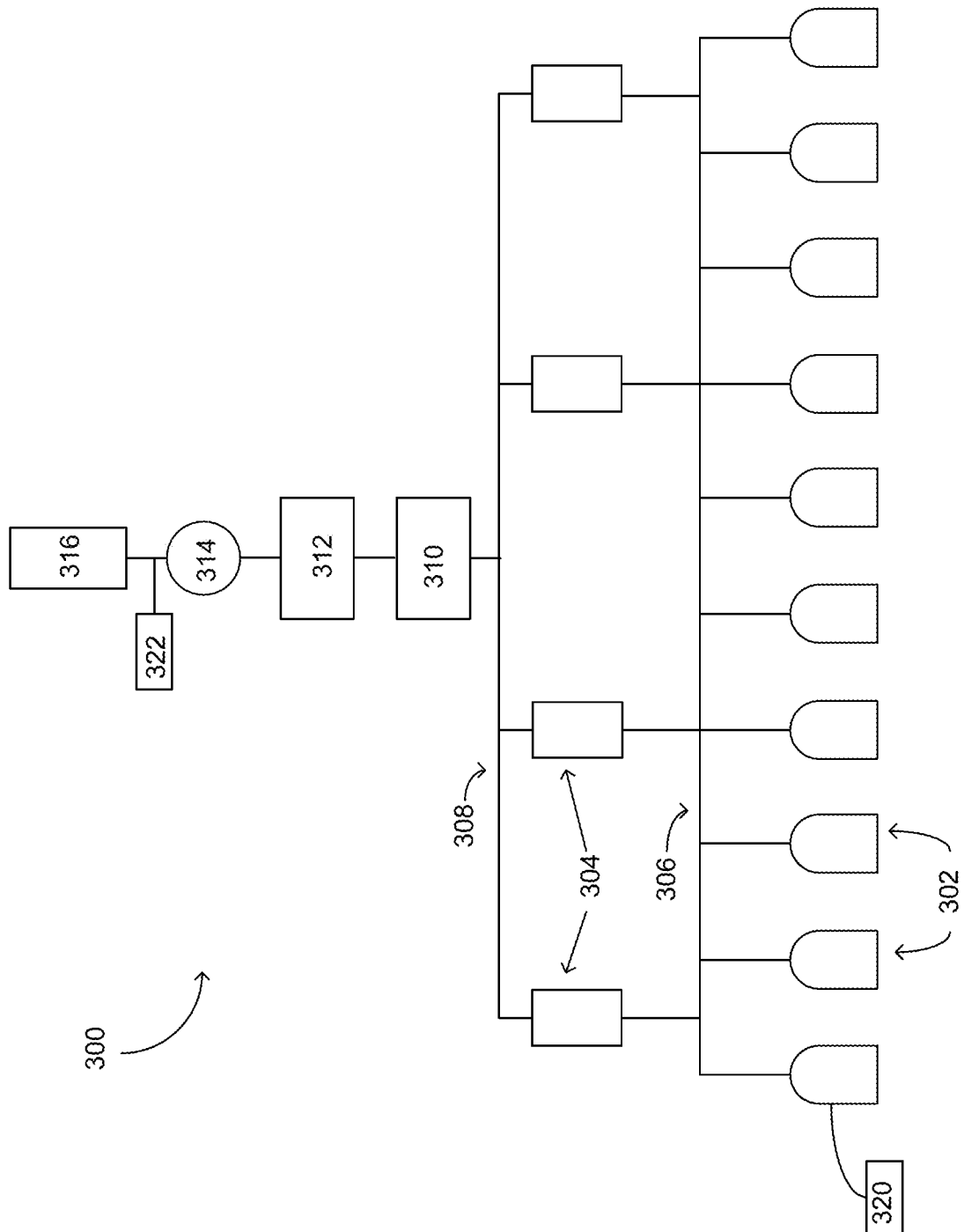


FIG. 3

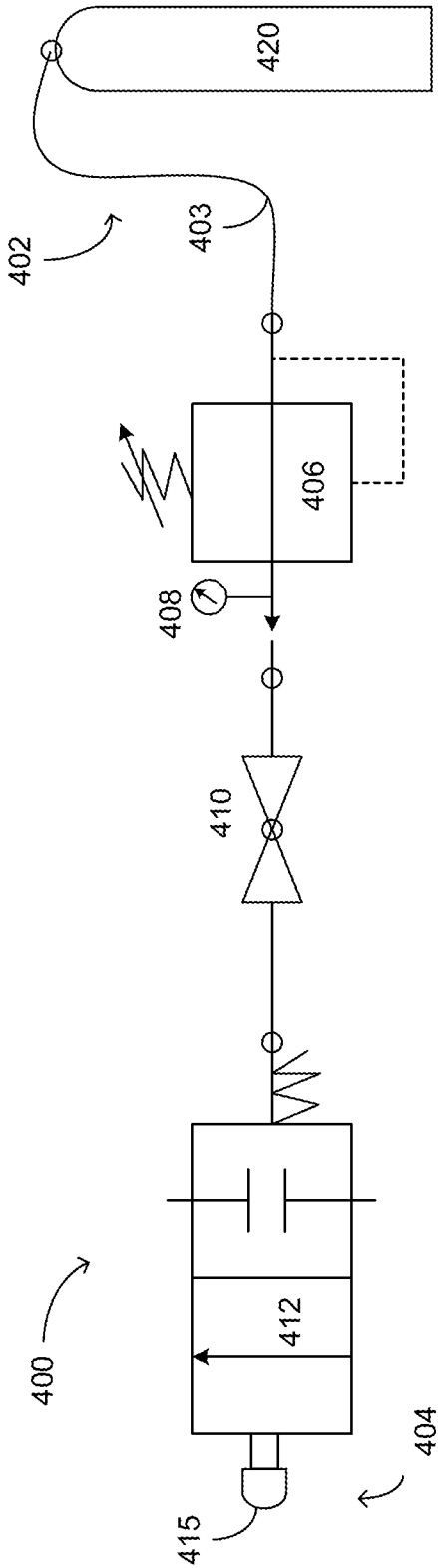


FIG. 4

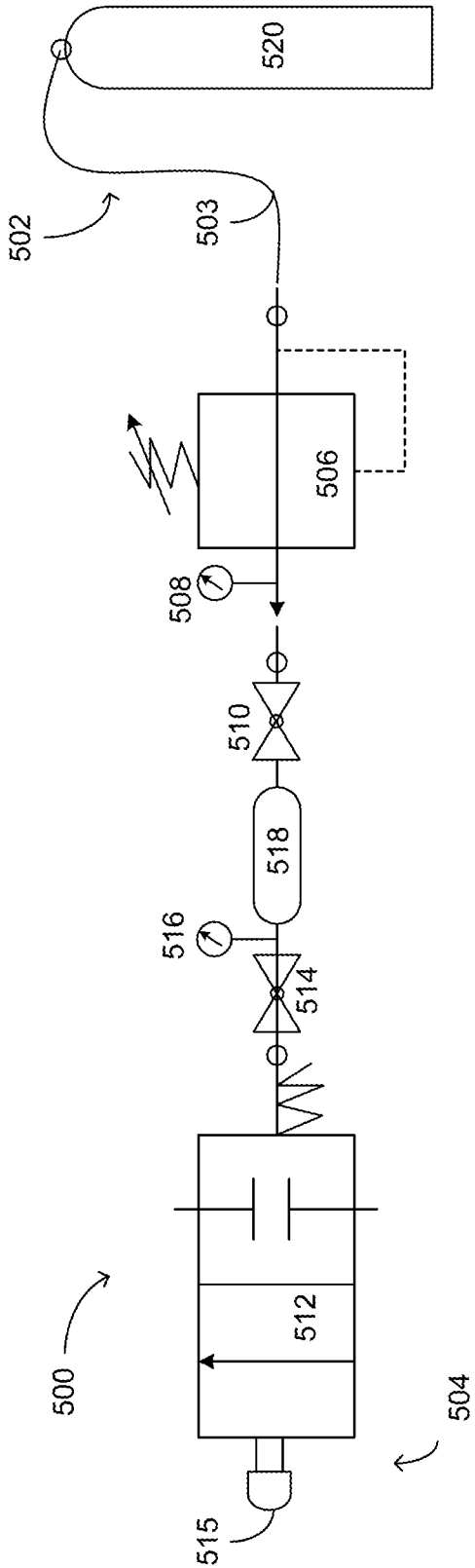
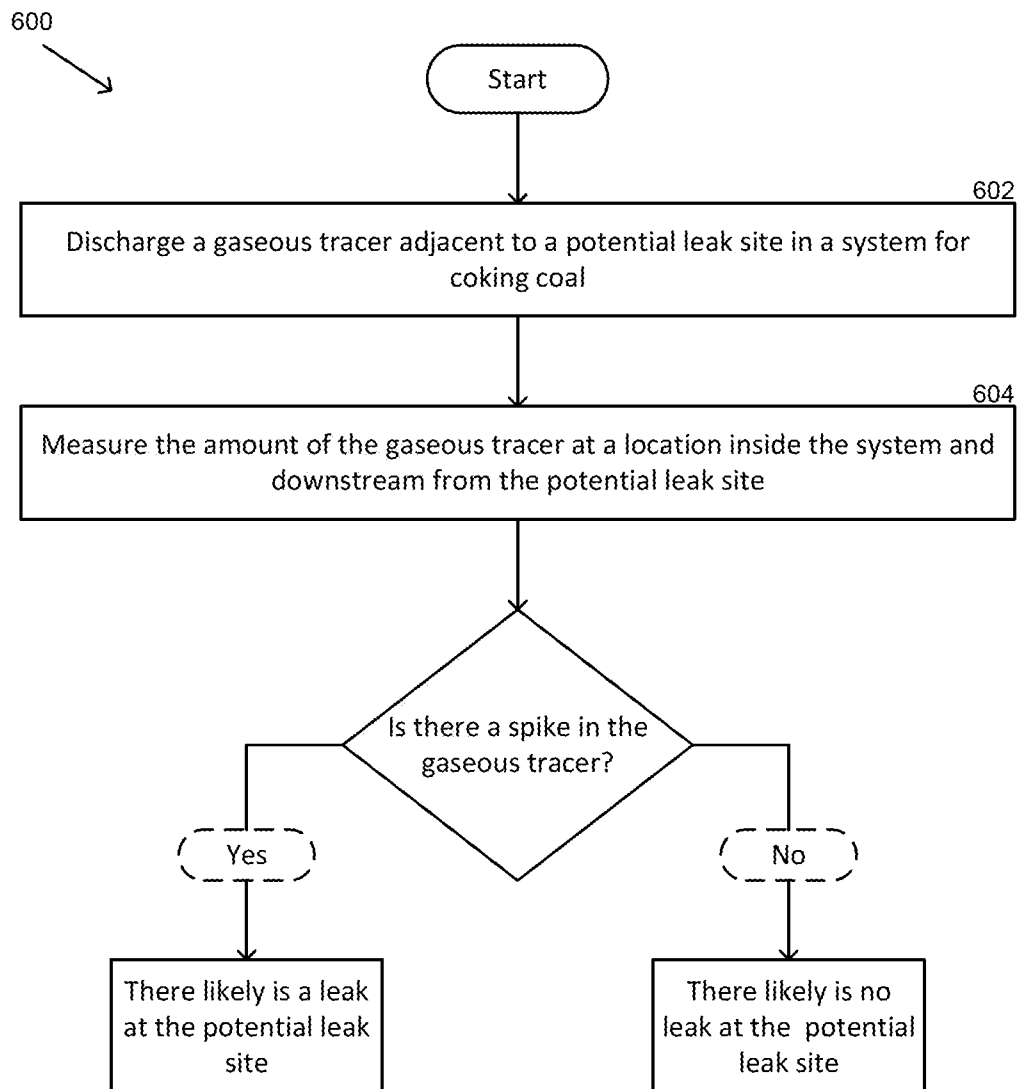
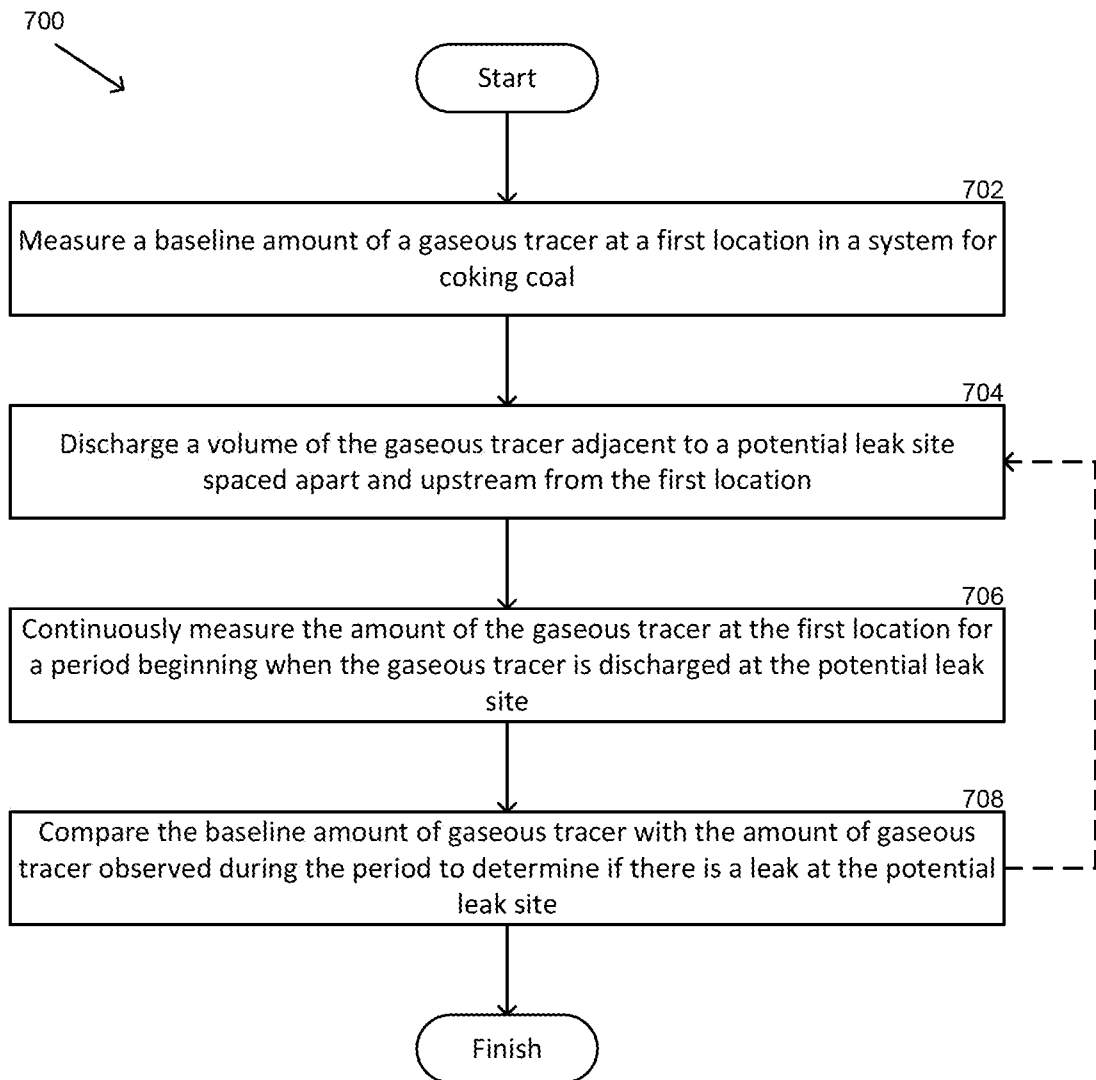


FIG. 5

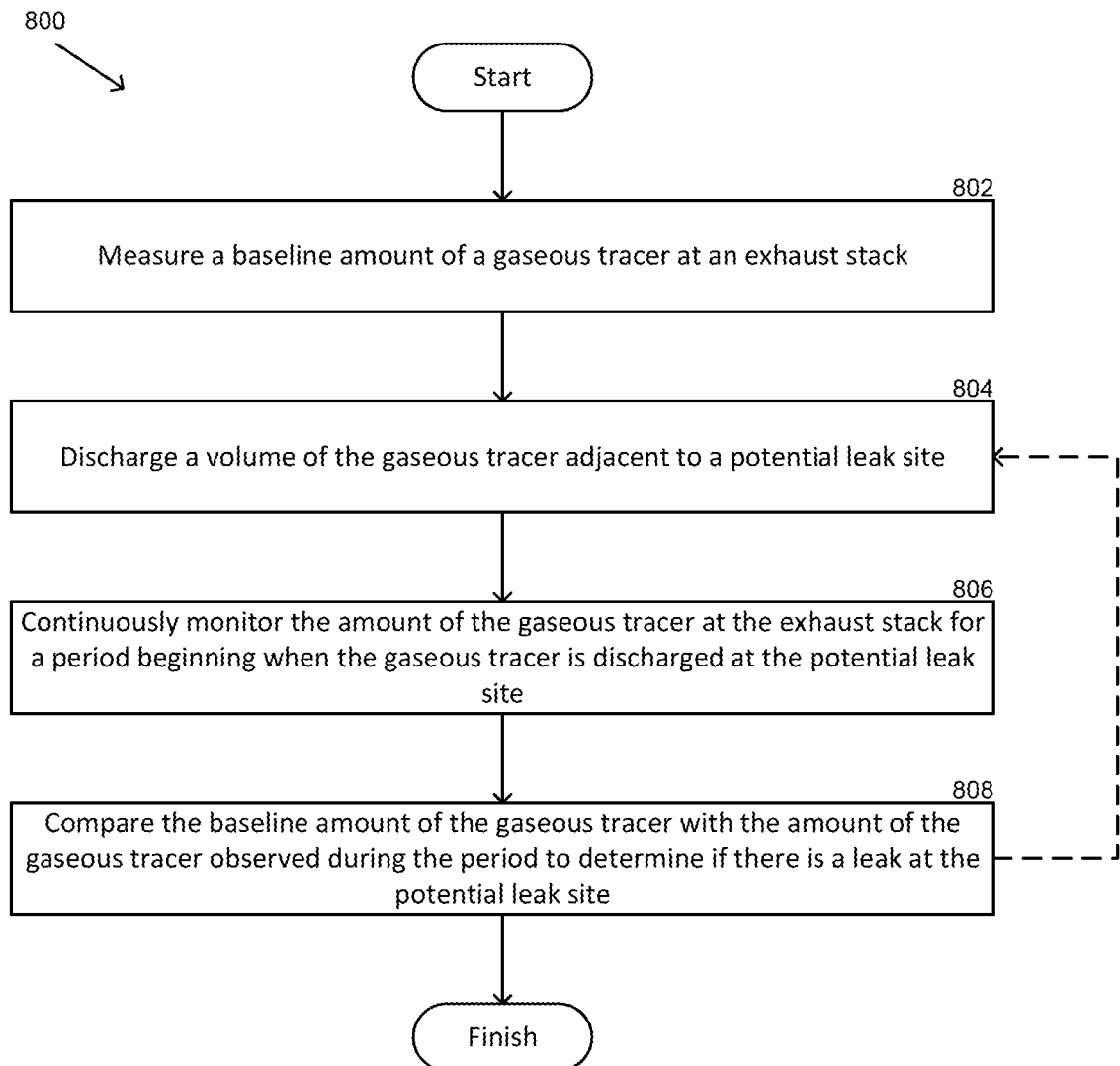
5/18

**FIG. 6**

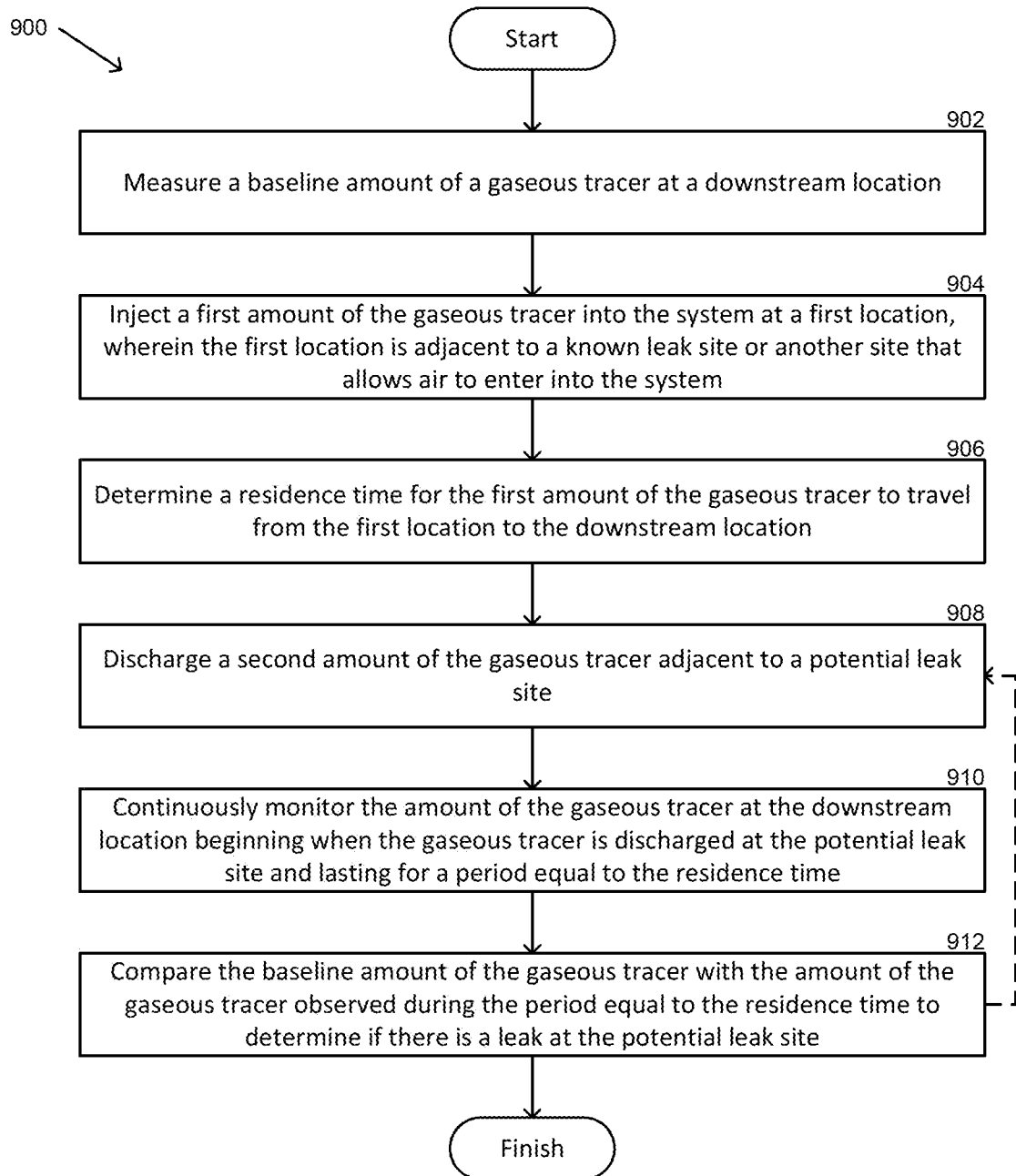
6/18

**FIG. 7**

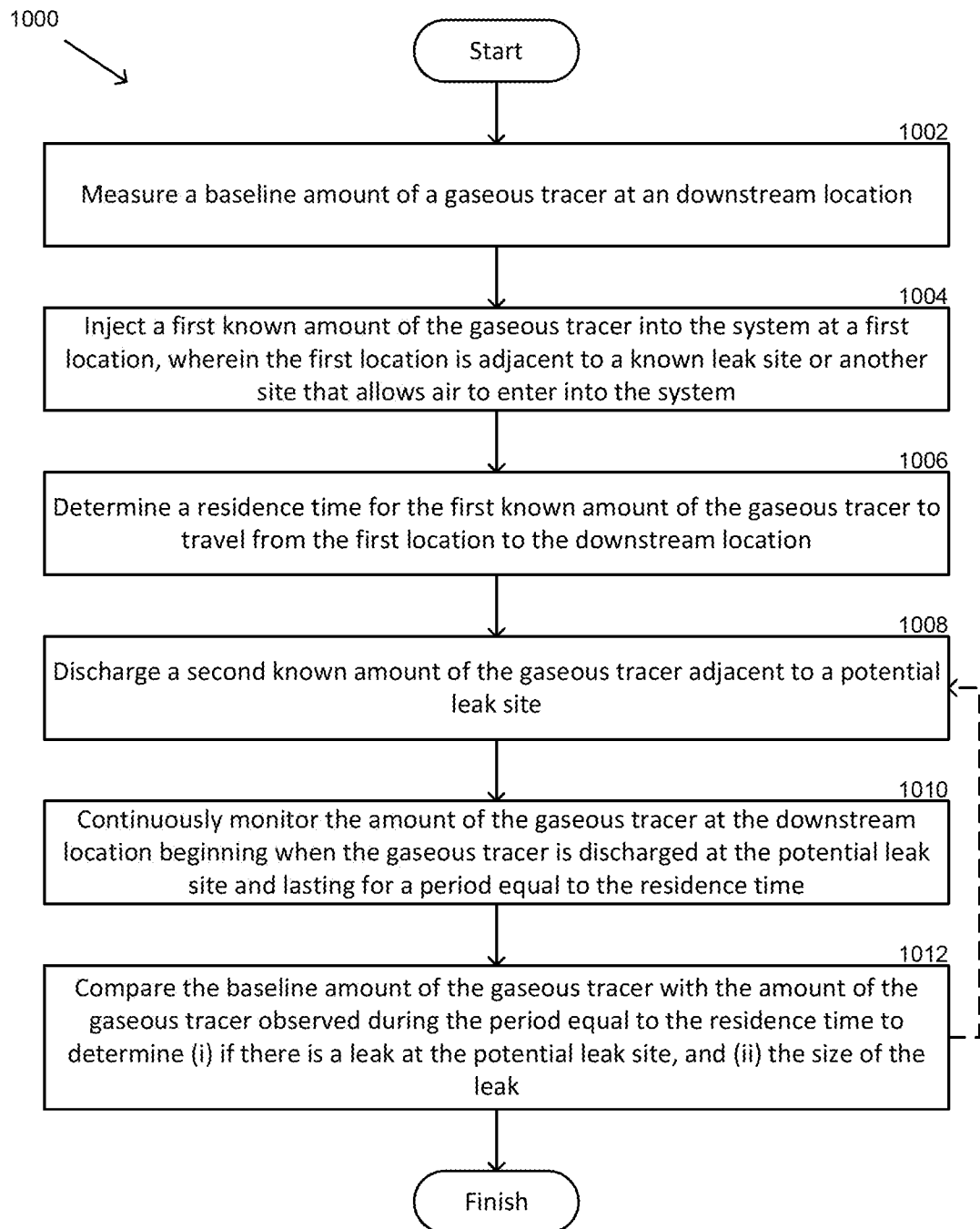
7/18

**FIG. 8**

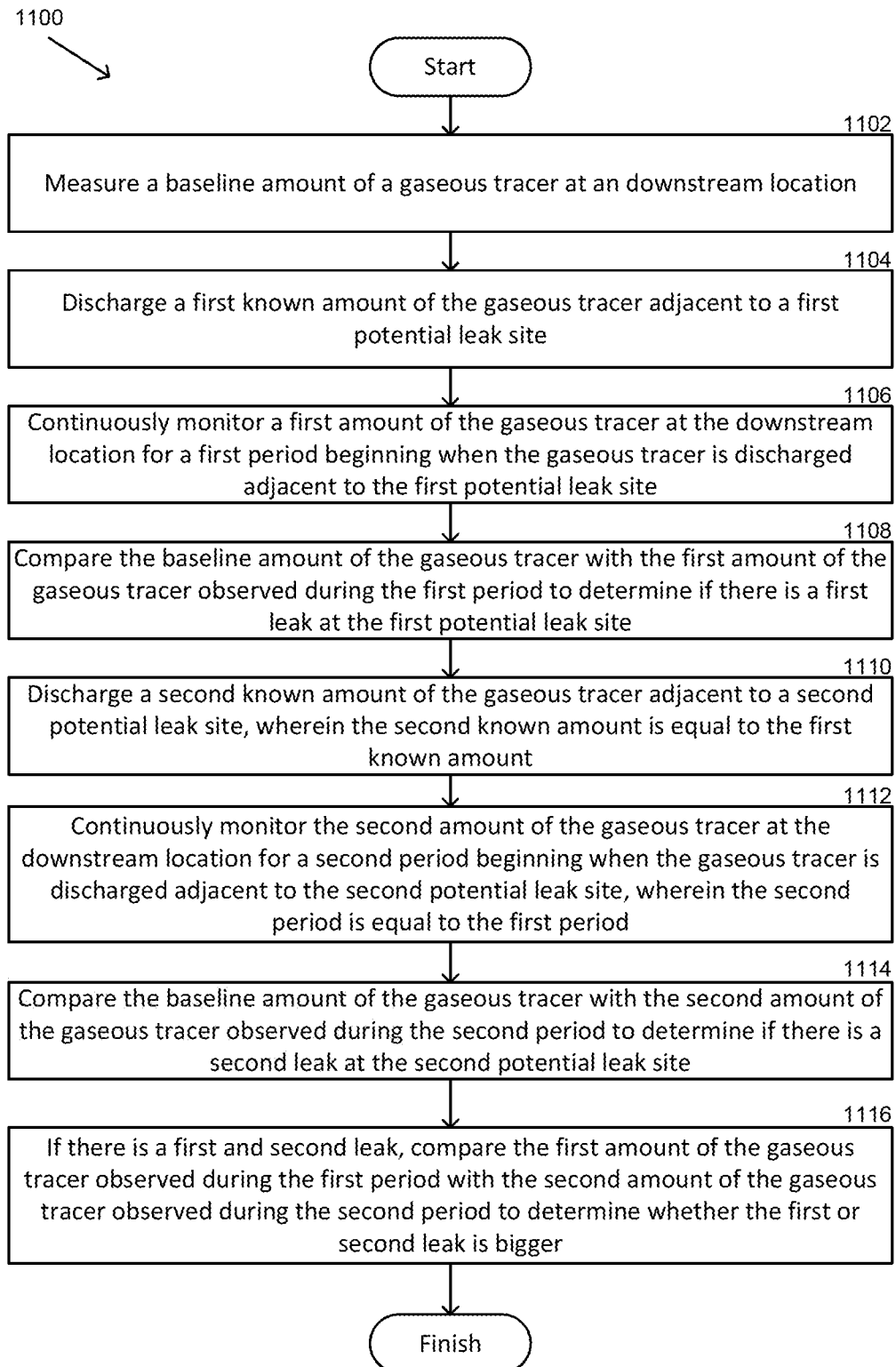
8/18

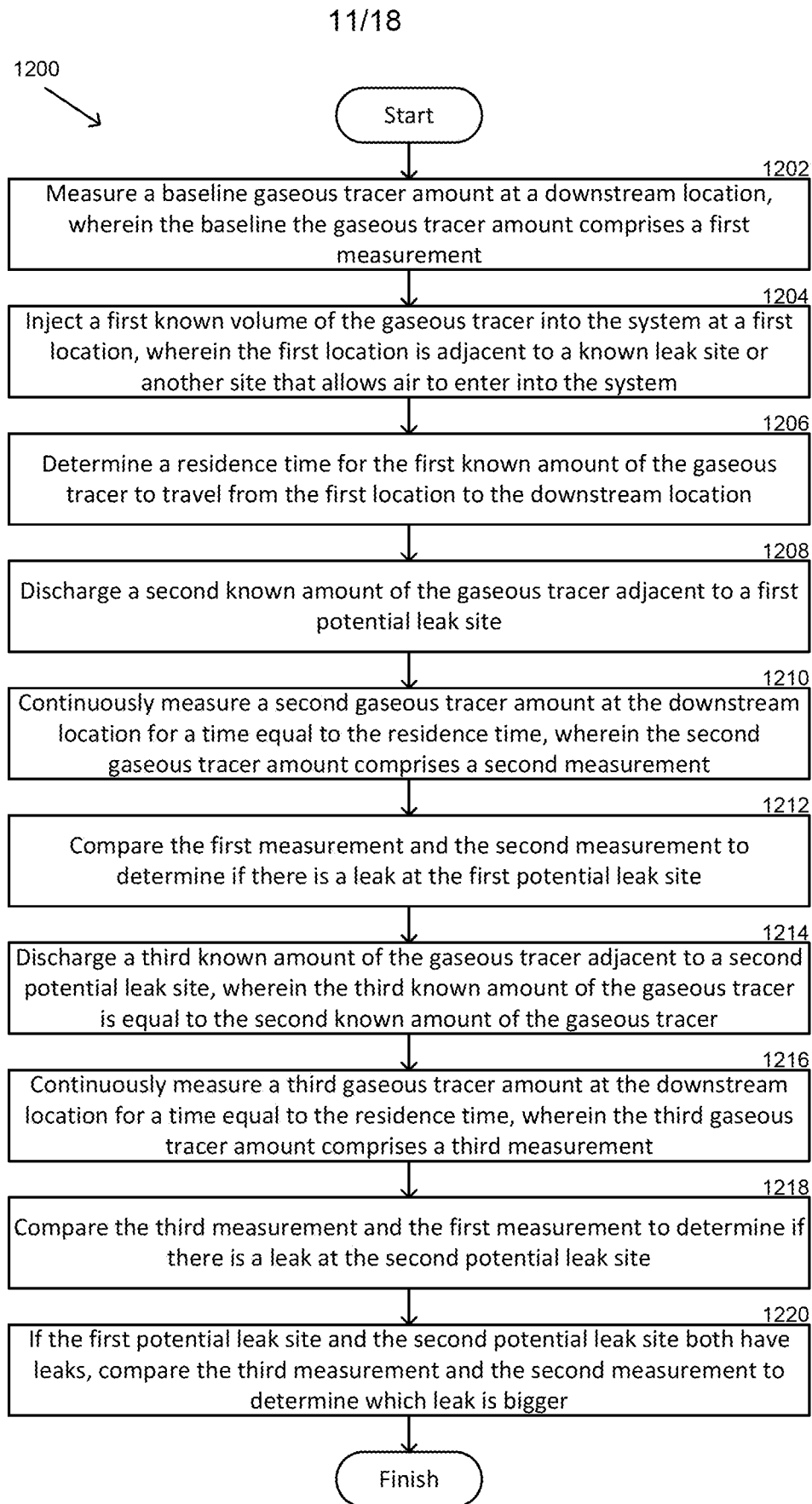
**FIG. 9**

9/18

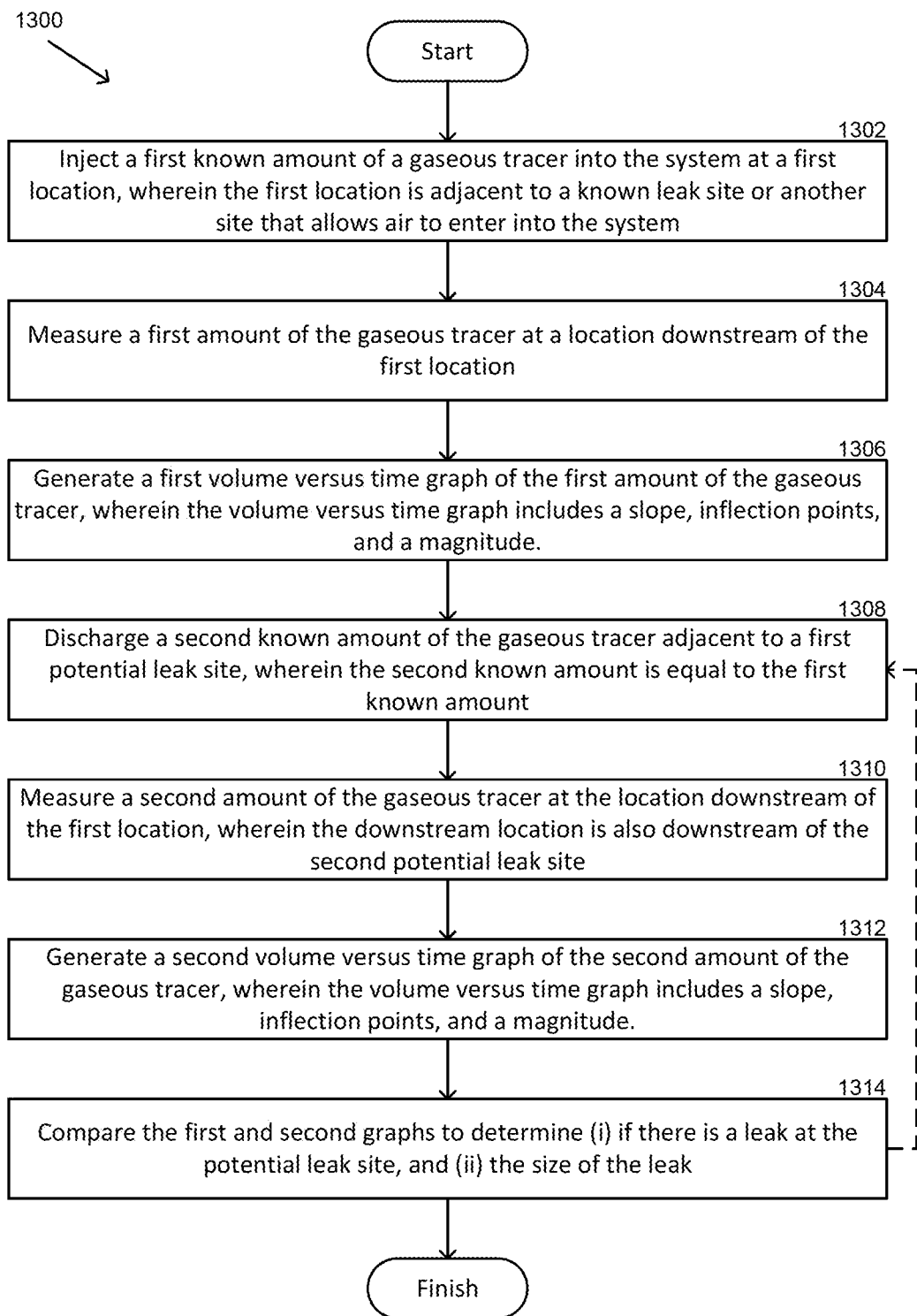
**FIG. 10**

10/18

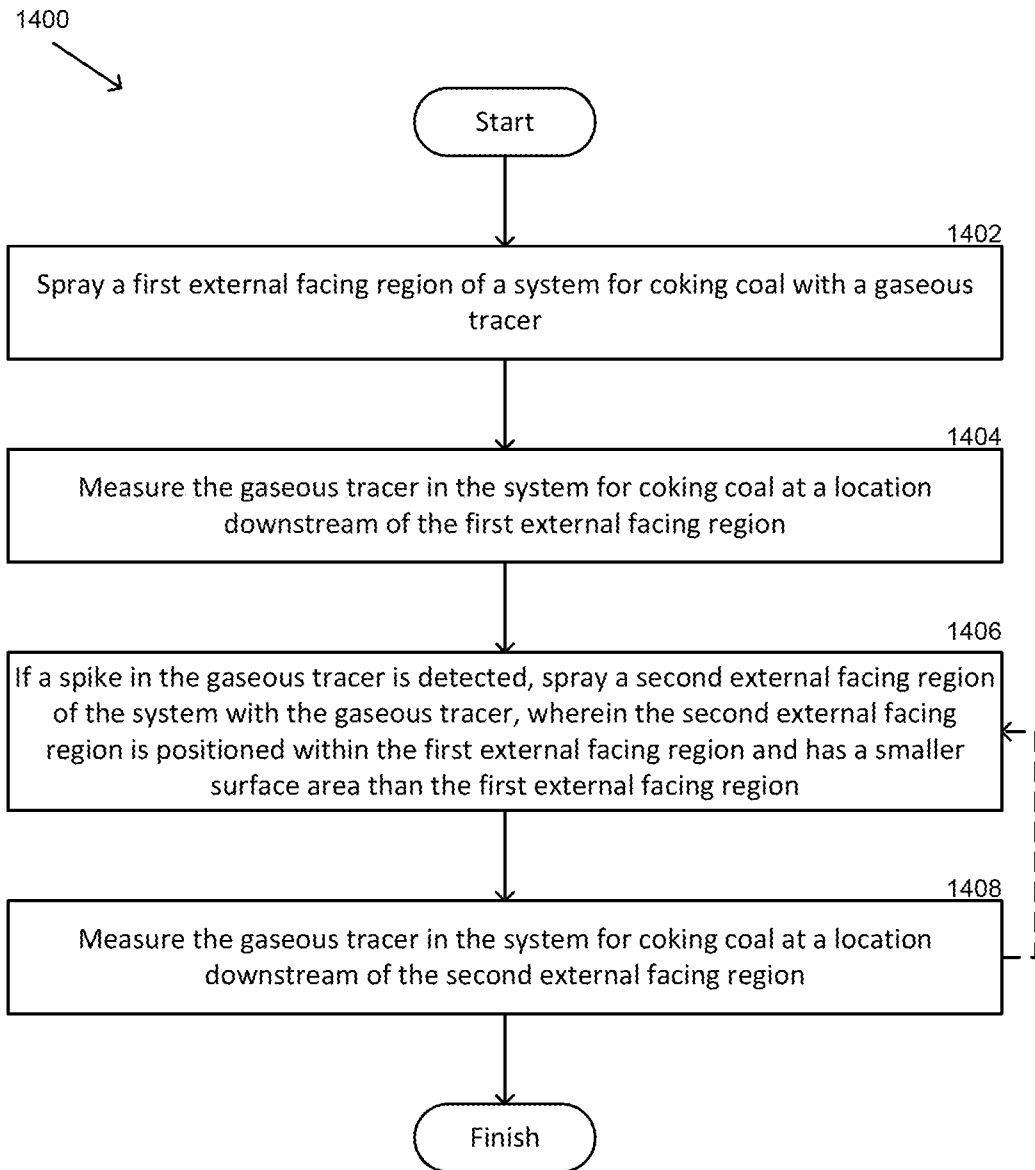
**FIG. 11**

**FIG. 12**

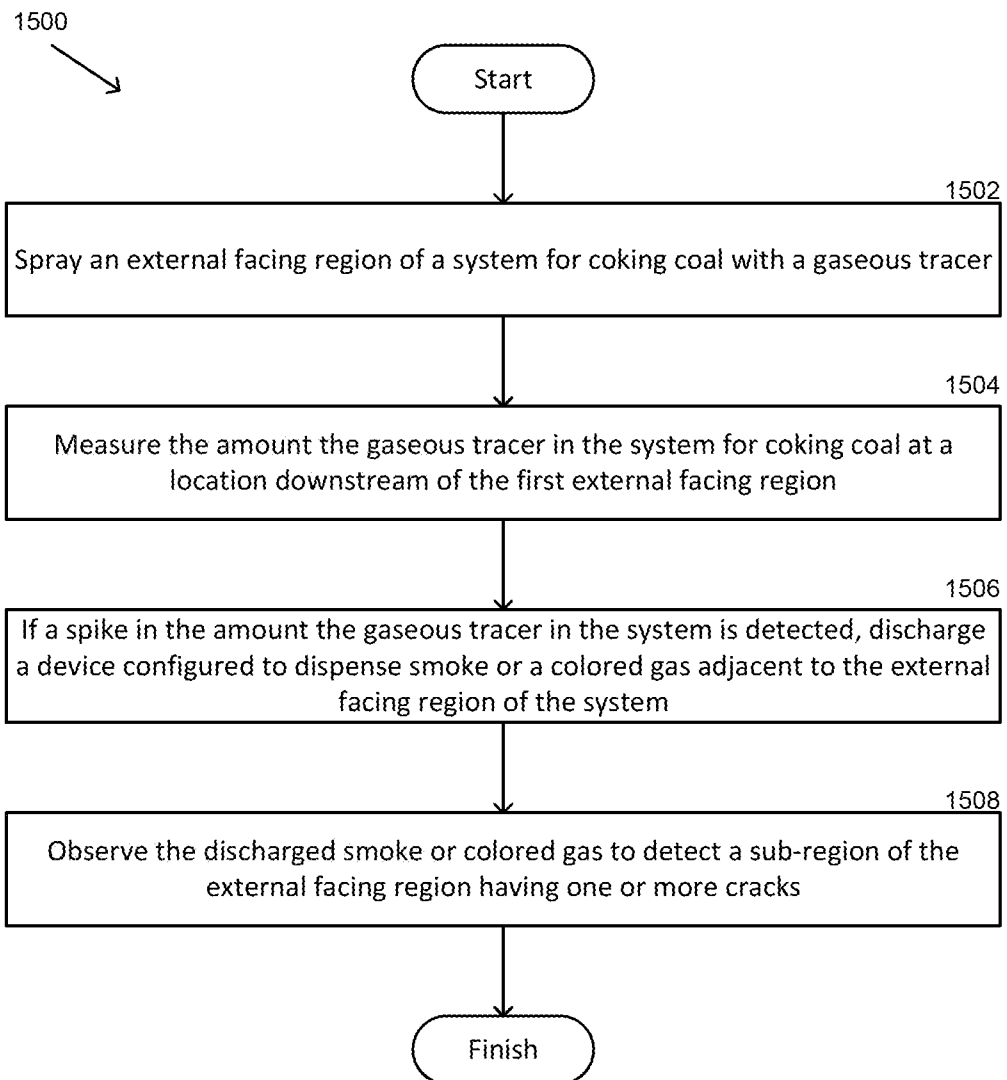
12/18

**FIG. 13**

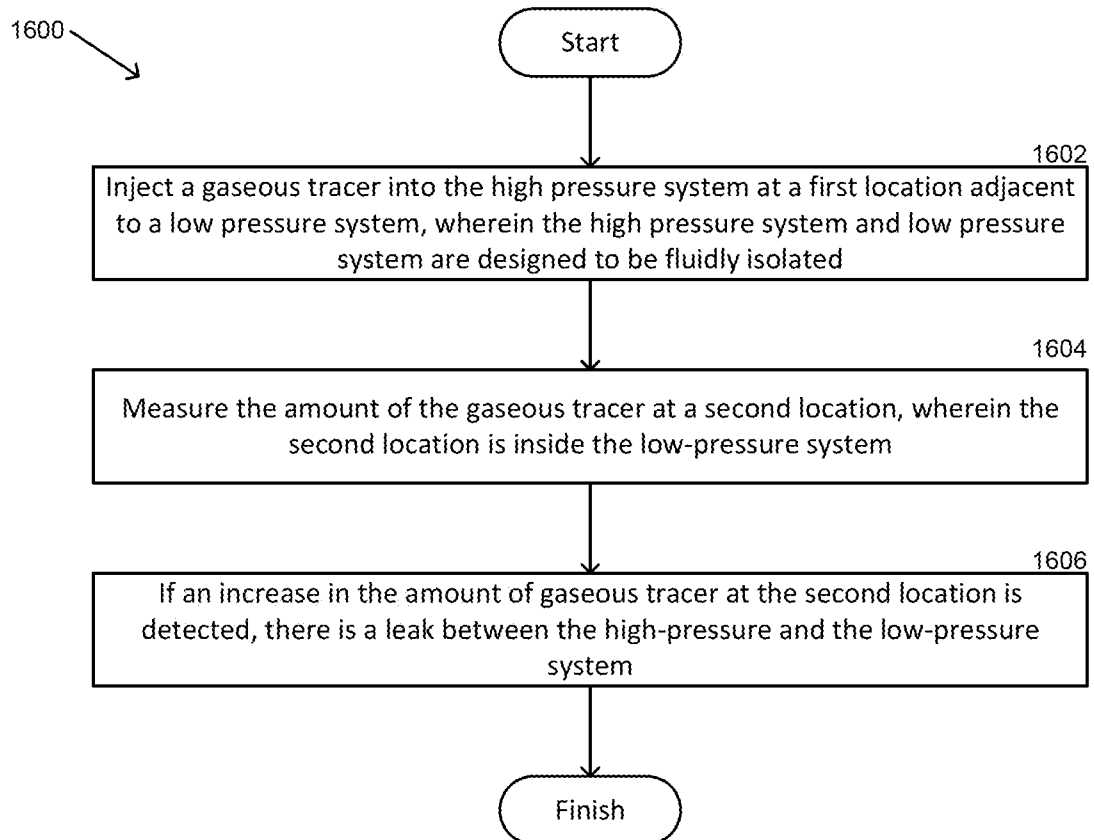
13/18

**FIG. 14**

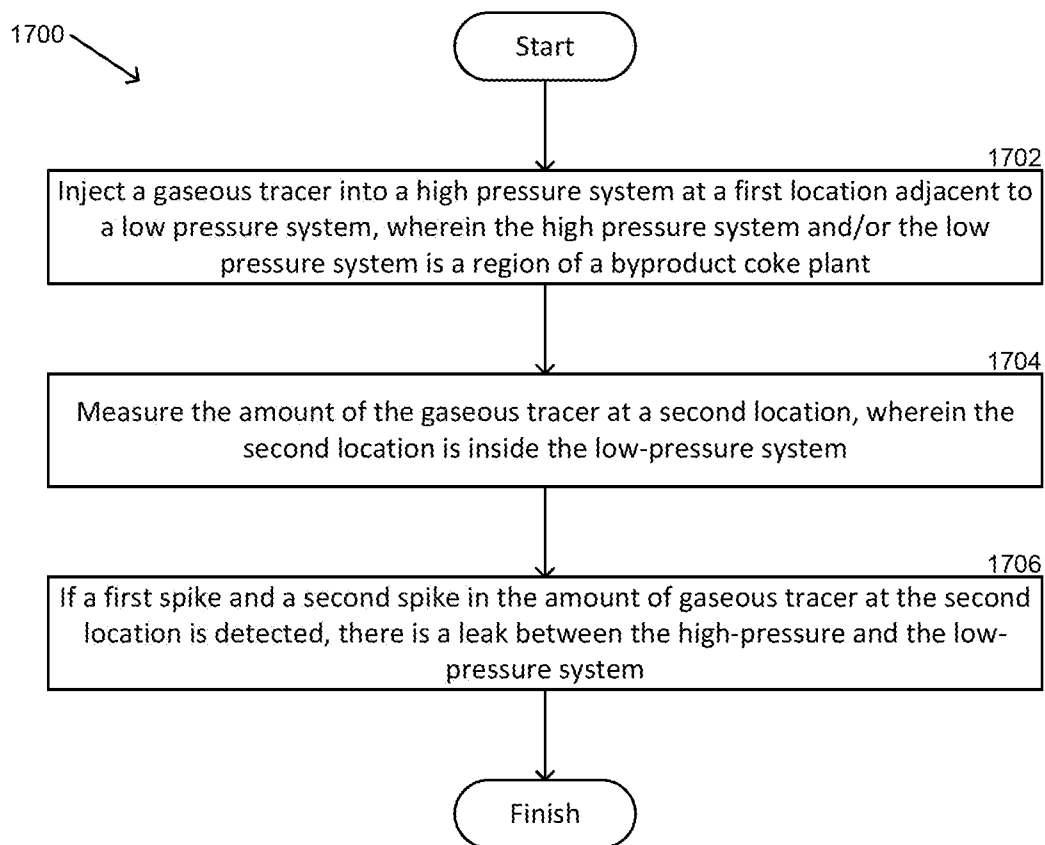
14/18

**FIG. 15**

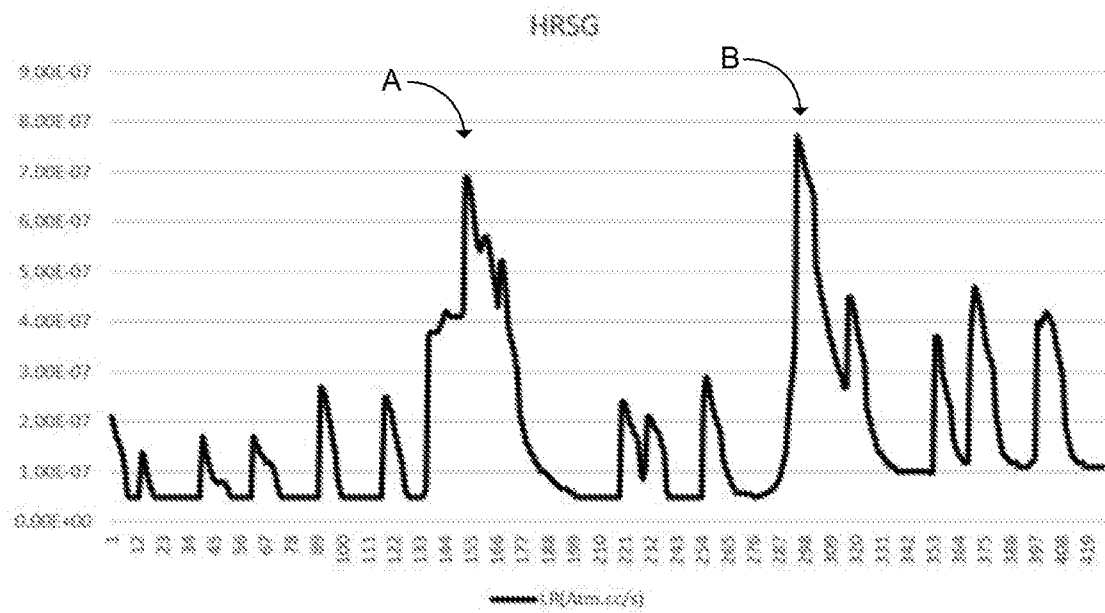
15/18

**FIG. 16**

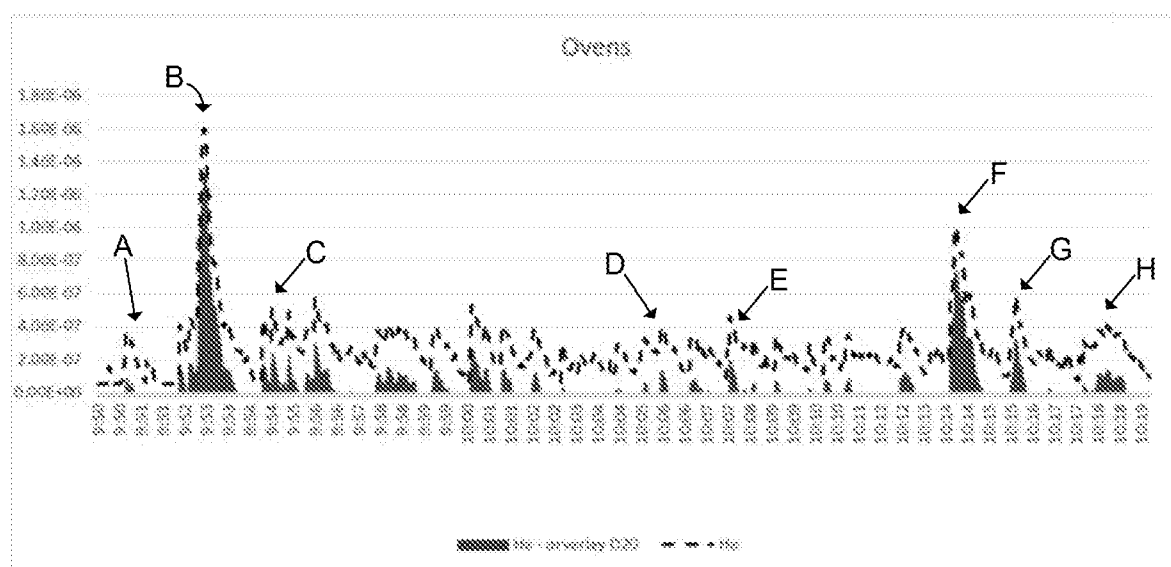
16/18

**FIG. 17**

17/18

**FIG. 18**

18/18

**FIG. 19**

