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(54) GASEOUS TRACER LEAK DETECTION

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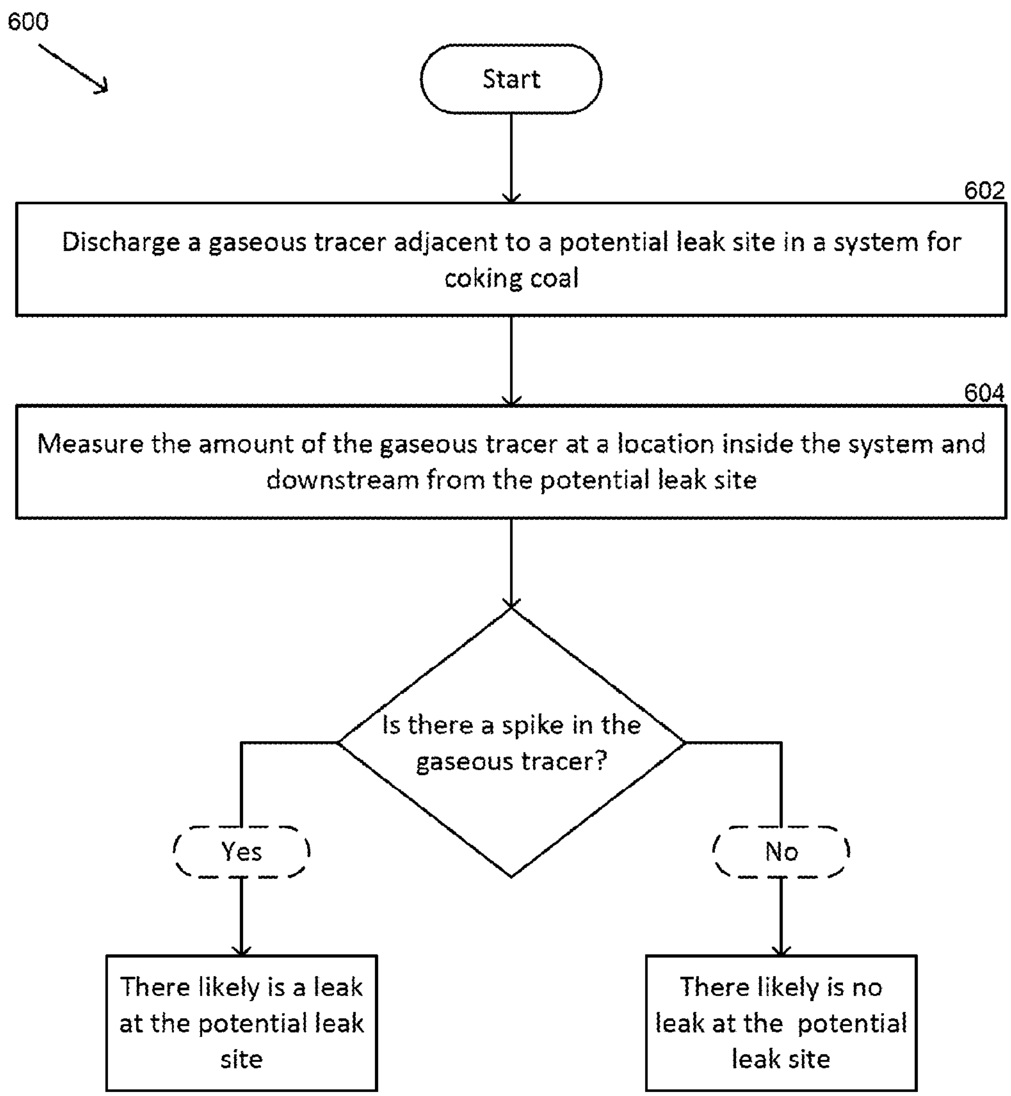
CPC ***C10B 41/00*** (2013.01); *C10B 29/06* (2013.01); ***G01M 3/207*** (2013.01); ***G01M 3/202*** (2013.01)

(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.



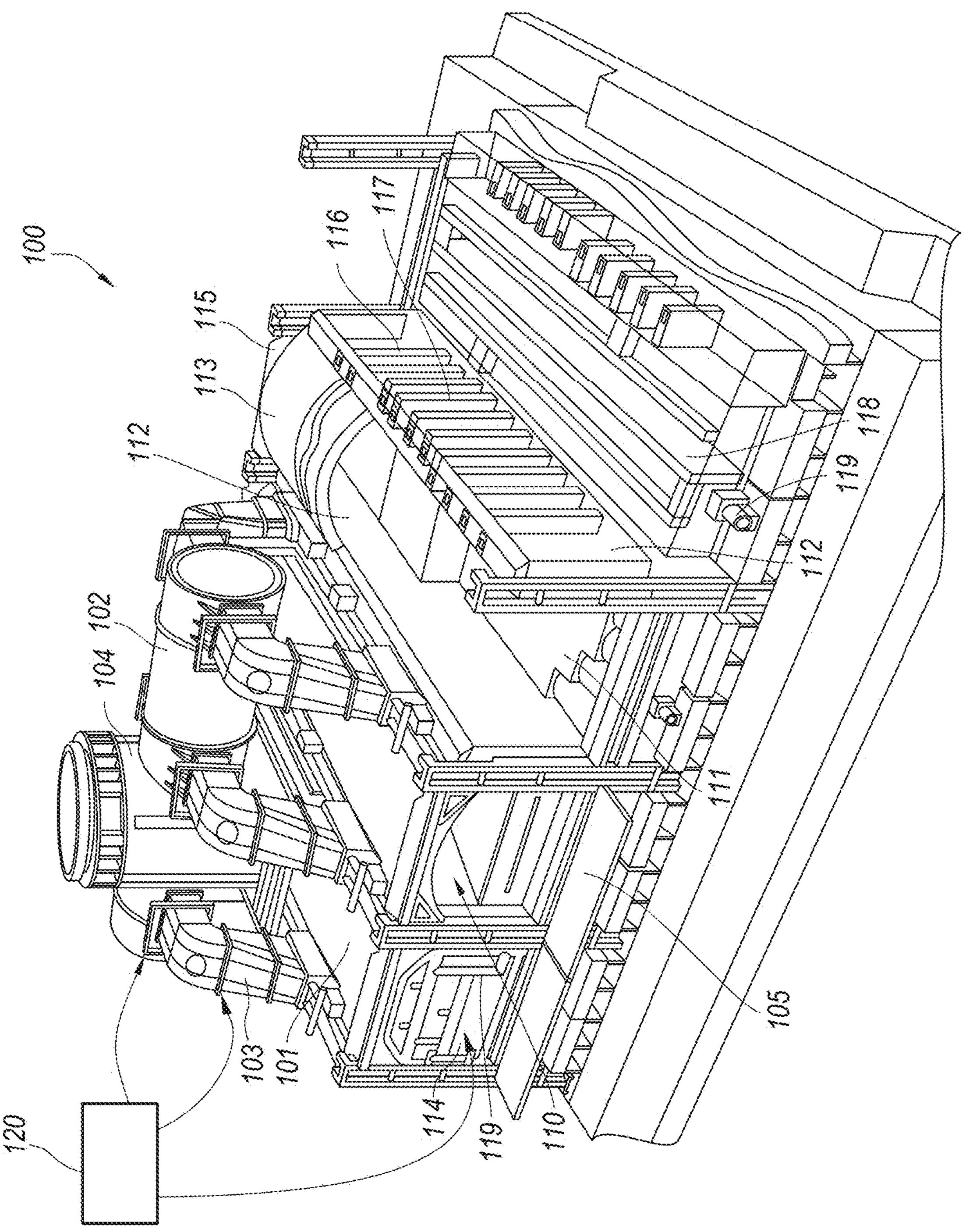

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FIG. 1

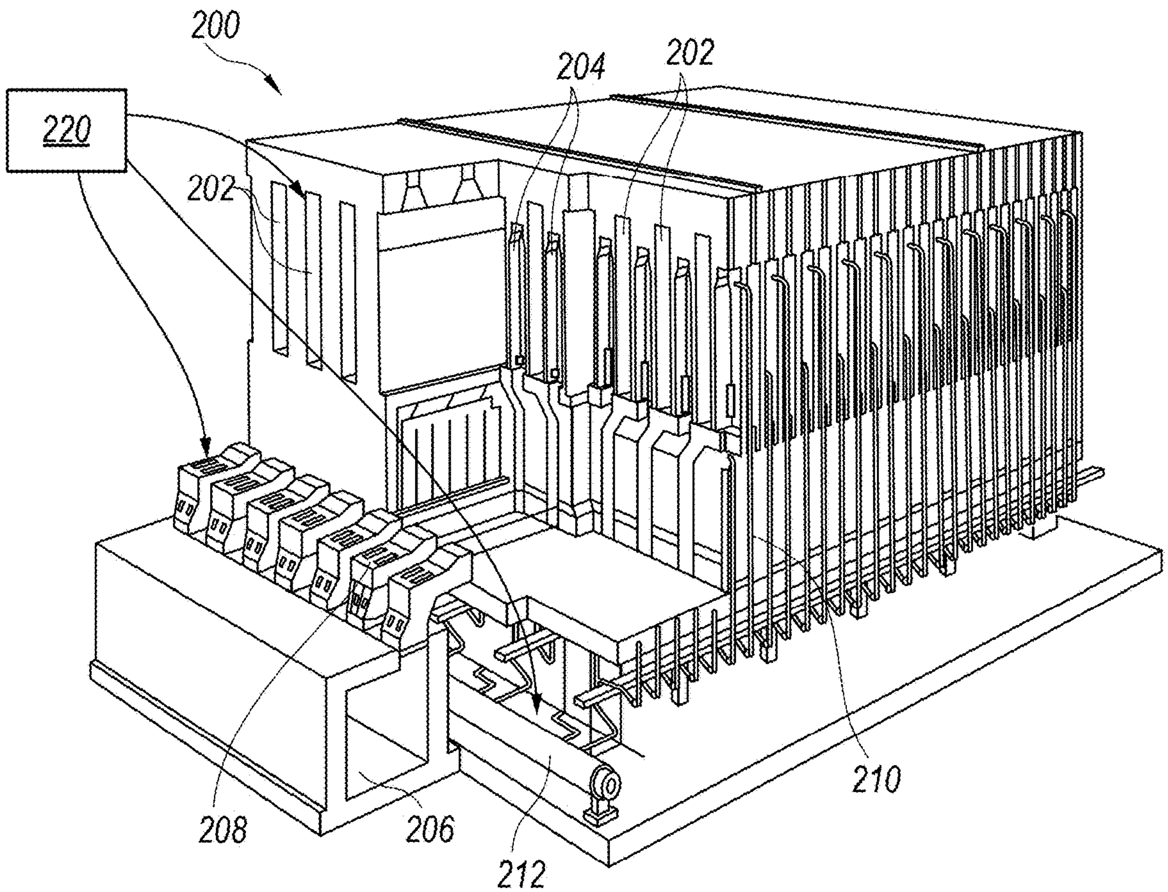
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FIG. 2A

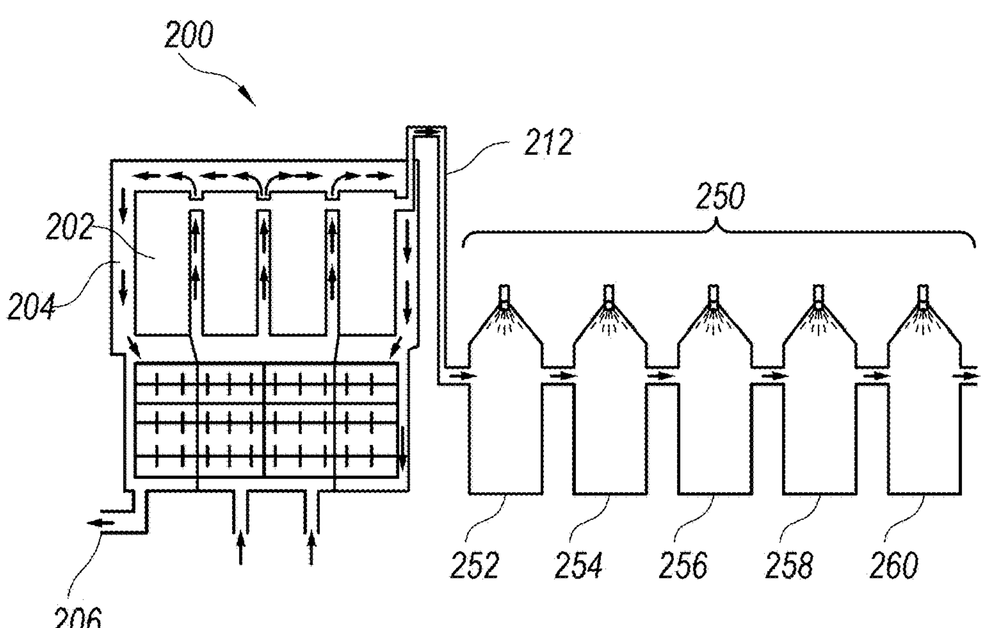
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FIG. 2B

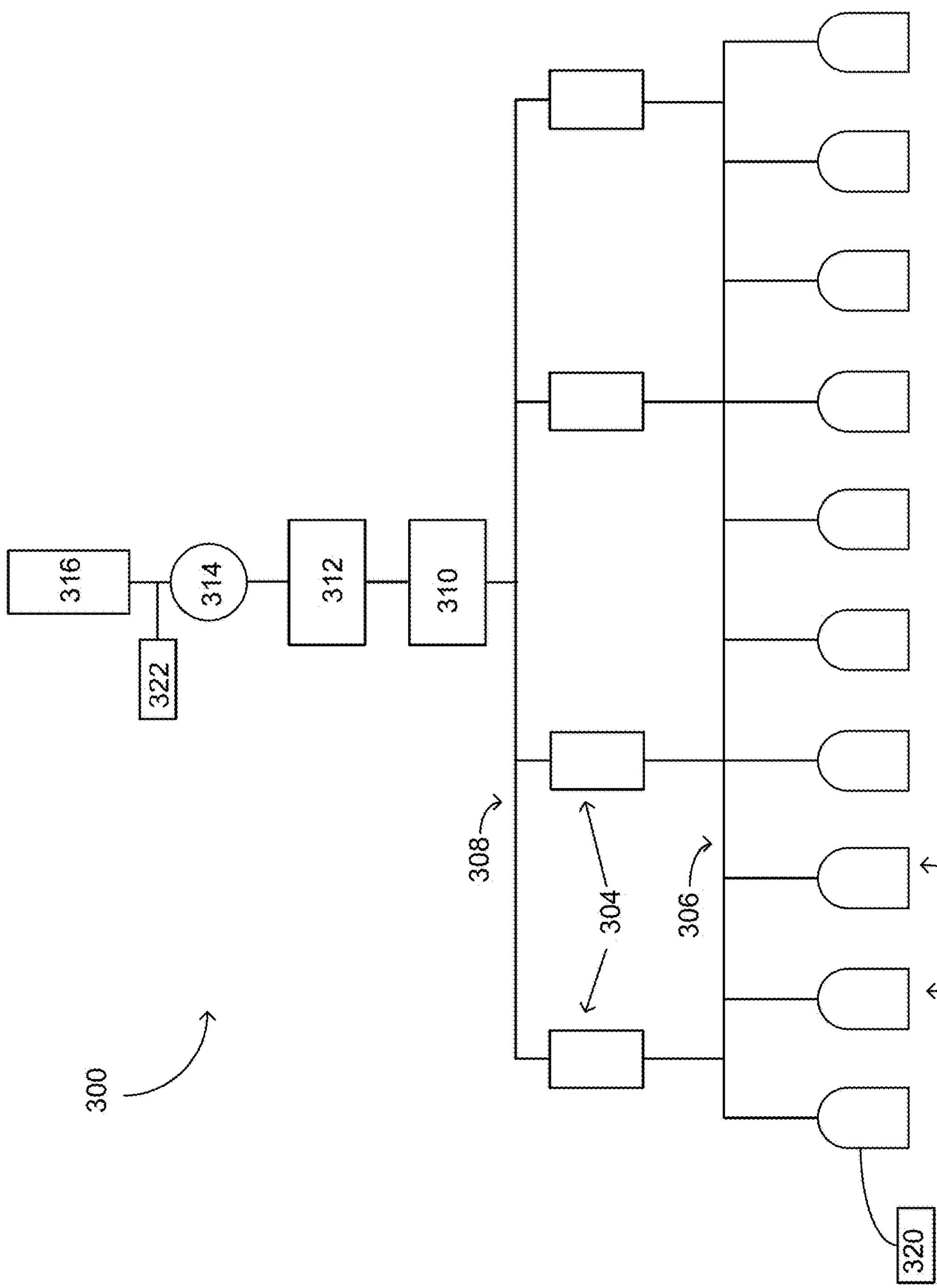

FIG. 3

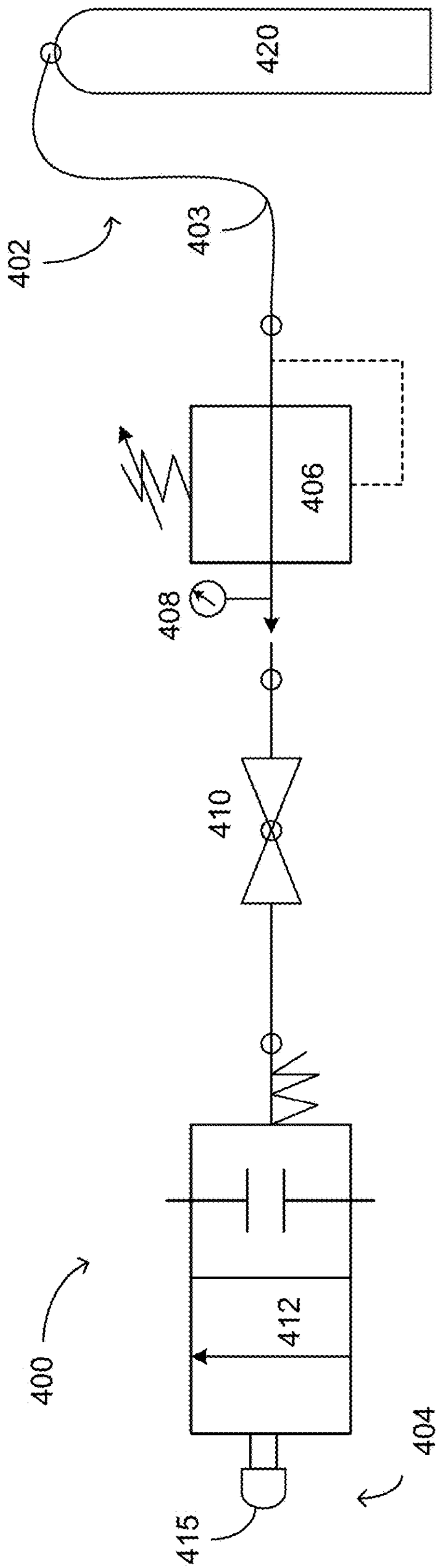
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FIG. 4

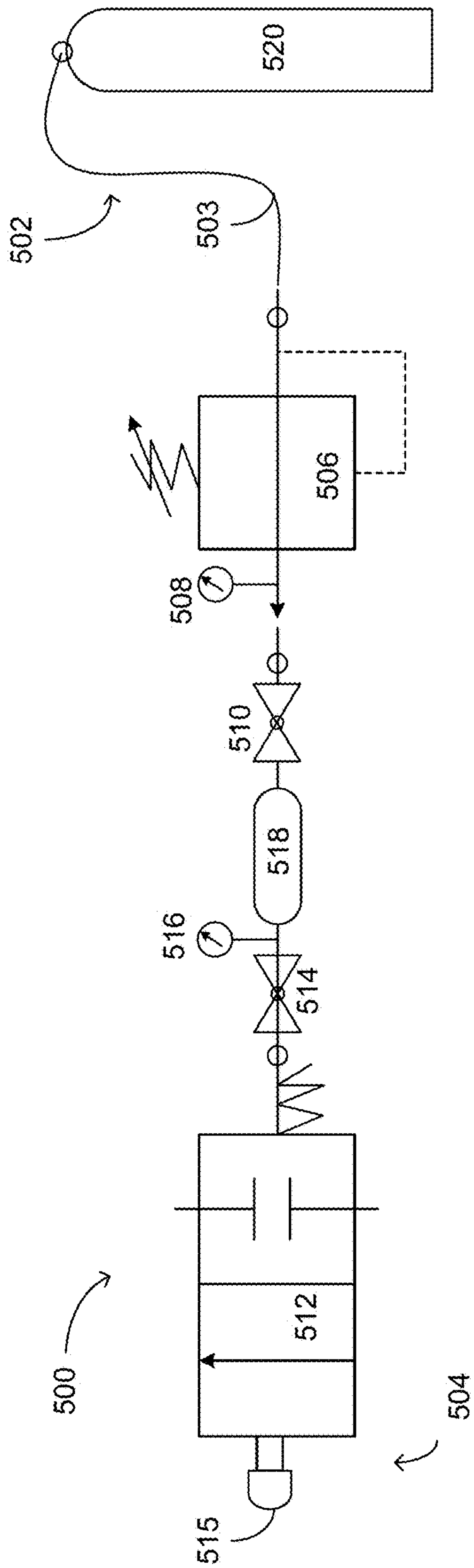
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FIG. 5

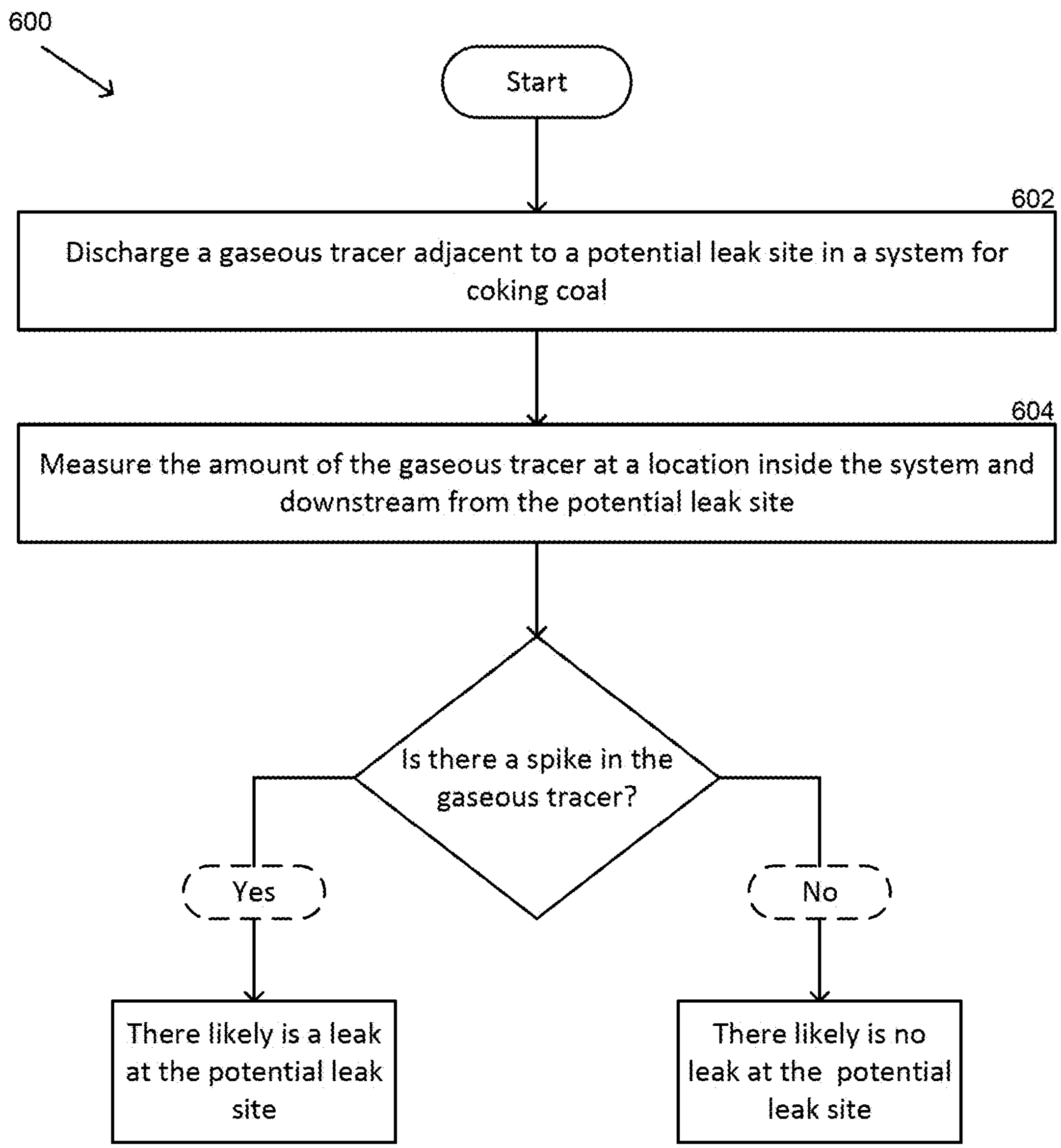

600
Start
602
Discharge a gaseous tracer adjacent to a potential leak site in a system for coking coal
604
Measure the amount of the gaseous tracer at a location inside the system and downstream from the potential leak site
Is there a spike in the gaseous tracer?
Yes
No
There likely is a leak at the potential leak site
There likely is no leak at the potential leak site

FIG. 6

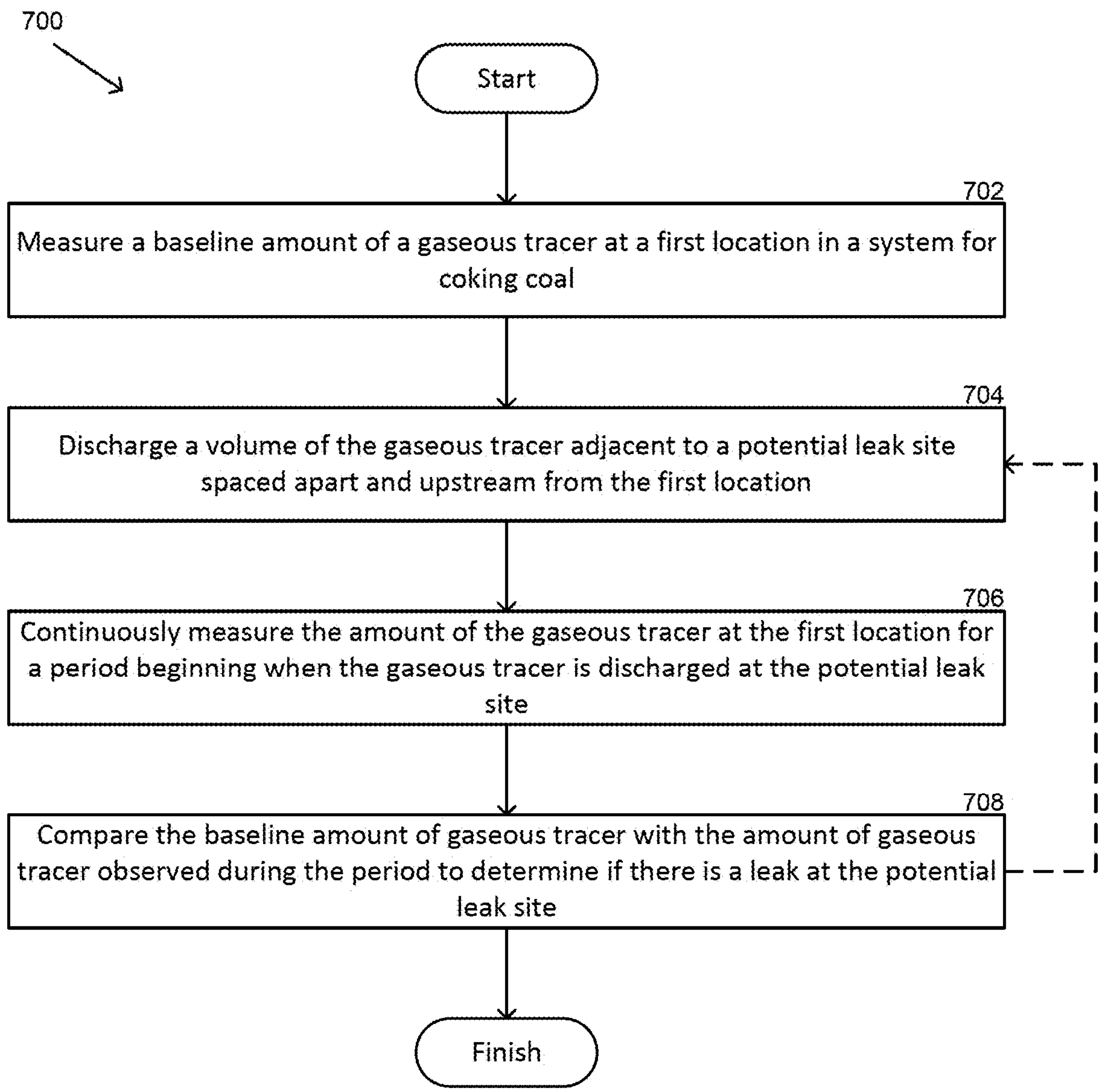

700
Start
702
Measure a baseline amount of a gaseous tracer at a first location in a system for coking coal
704
Discharge a volume of the gaseous tracer adjacent to a potential leak site spaced apart and upstream from the first location
706
Continuously measure the amount of the gaseous tracer at the first location for a period beginning when the gaseous tracer is discharged at the potential leak site
708
Compare 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
Finish

FIG. 7

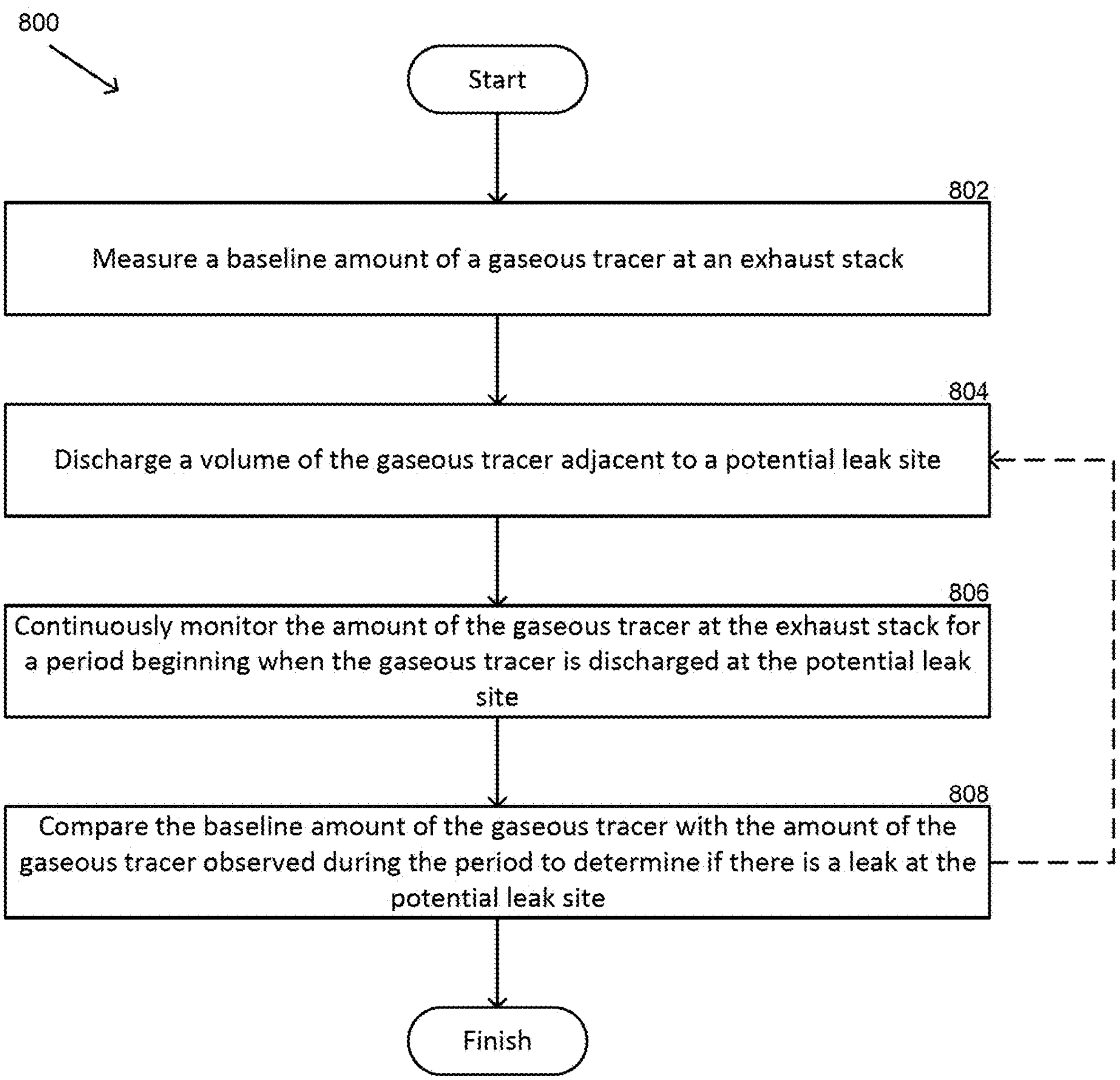

800
Start
802
Measure a baseline amount of a gaseous tracer at an exhaust stack
804
Discharge a volume of the gaseous tracer adjacent to a potential leak site
806
Continuously monitor the amount of the gaseous tracer at the exhaust stack for a period beginning when the gaseous tracer is discharged at the potential leak site
808
Compare the baseline amount of the gaseous tracer with the amount of the gaseous tracer observed during the period to determine if there is a leak at the potential leak site
Finish

FIG. 8

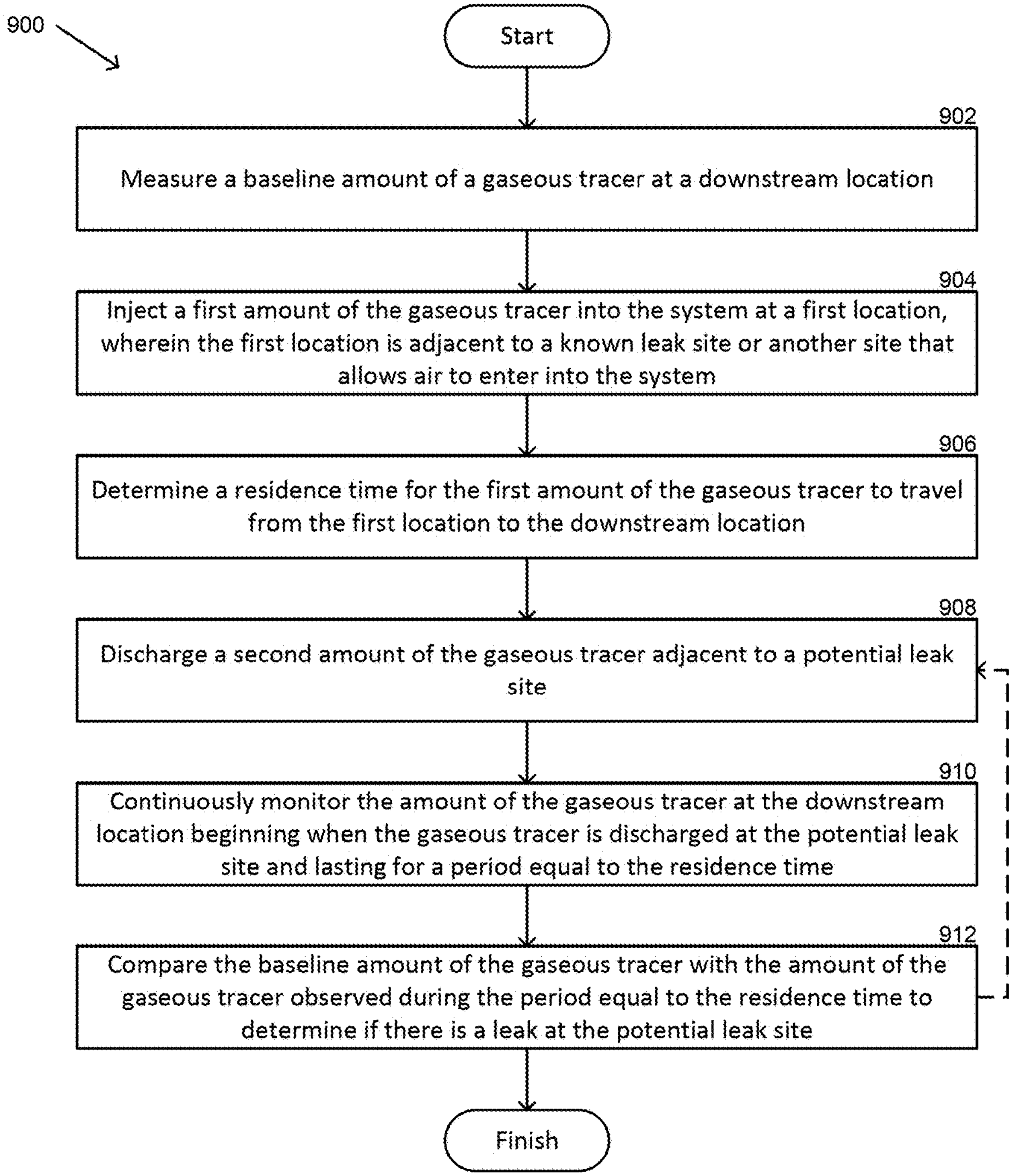

900
Start
902
Measure a baseline amount of a gaseous tracer at a downstream location
904
Inject a first amount of the gaseous tracer into the system at a first location, wherein the first location is adjacent to a known leak site or another site that allows air to enter into the system
906
Determine a residence time for the first amount of the gaseous tracer to travel from the first location to the downstream location
908
Discharge a second amount of the gaseous tracer adjacent to a potential leak site
910
Continuously monitor 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
912
Compare 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
Finish

FIG. 9

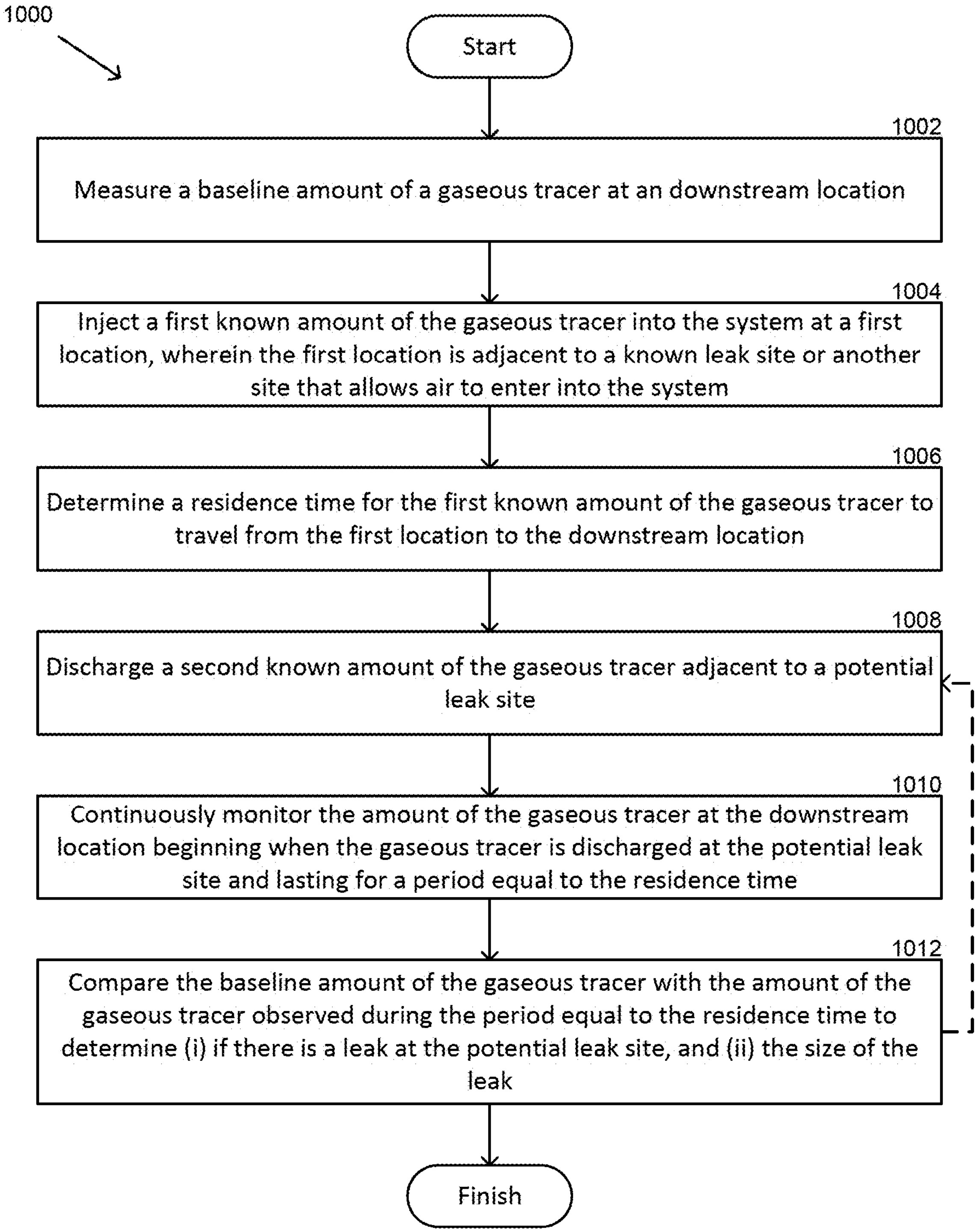

1000
Start
1002
Measure a baseline amount of a gaseous tracer at an downstream location
1004
Inject a first known amount of the gaseous tracer into the system at a first location, wherein the first location is adjacent to a known leak site or another site that allows air to enter into the system
1006
Determine a residence time for the first known amount of the gaseous tracer to travel from the first location to the downstream location
1008
Discharge a second known amount of the gaseous tracer adjacent to a potential leak site
1010
Continuously monitor 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
1012
Compare 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
Finish

FIG. 10

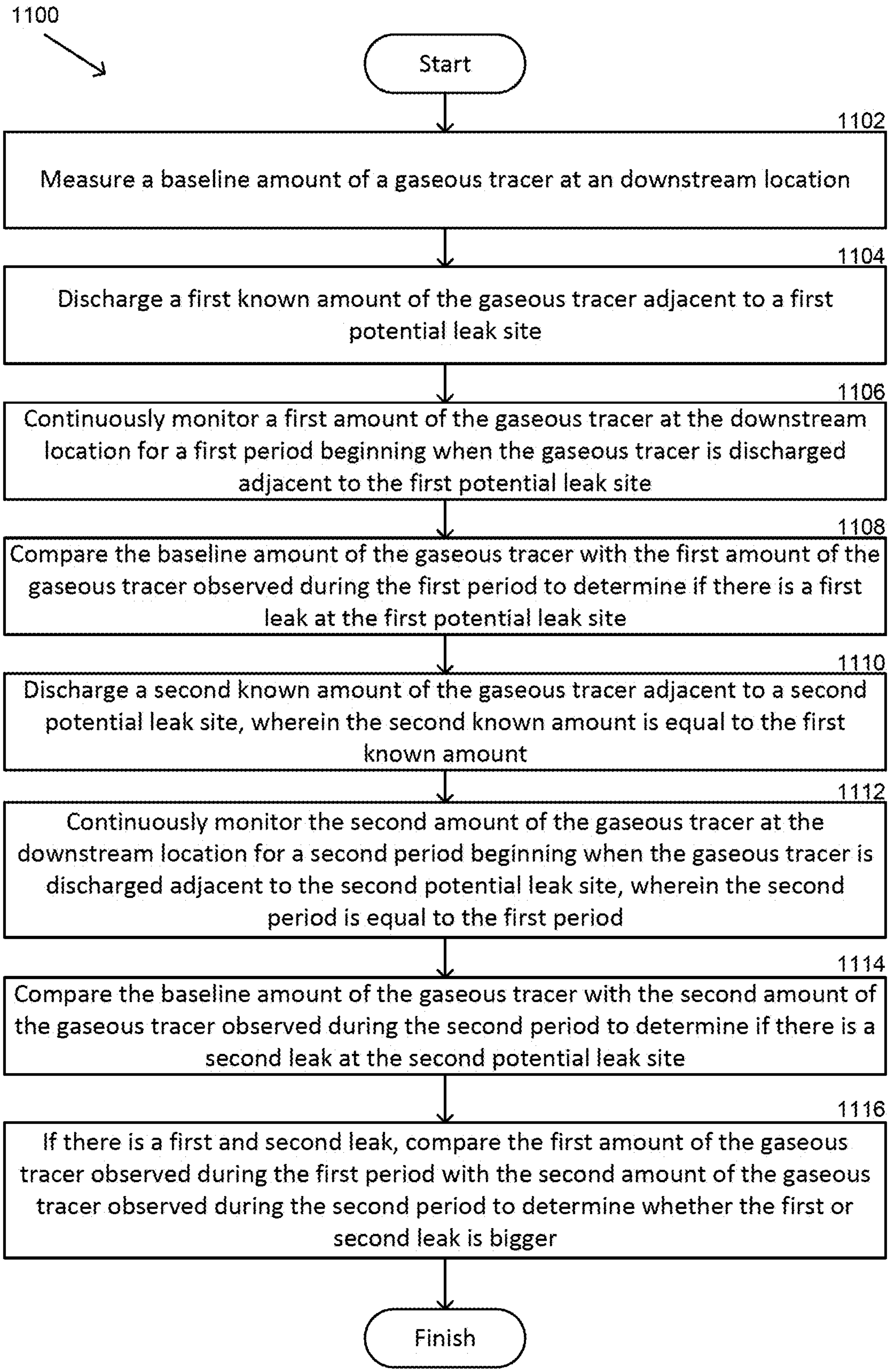

1100
Start
1102
Measure a baseline amount of a gaseous tracer at an downstream location
1104
Discharge a first known amount of the gaseous tracer adjacent to a first potential leak site
1106
Continuously monitor a first amount of the gaseous tracer at the downstream location for a first period beginning when the gaseous tracer is discharged adjacent to the first potential leak site
1108
Compare the baseline amount of the gaseous tracer with the first amount of the gaseous tracer observed during the first period to determine if there is a first leak at the first potential leak site
1110
Discharge a second known amount of the gaseous tracer adjacent to a second potential leak site, wherein the second known amount is equal to the first known amount
1112
Continuously monitor the second amount of the gaseous tracer at the downstream location for a second period beginning when the gaseous tracer is discharged adjacent to the second potential leak site, wherein the second period is equal to the first period
1114
Compare the baseline amount of the gaseous tracer with the second amount of the gaseous tracer observed during the second period to determine if there is a second leak at the second potential leak site
1116
If there is a first and second leak, compare the first amount of the gaseous tracer observed during the first period with the second amount of the gaseous tracer observed during the second period to determine whether the first or second leak is bigger
Finish

FIG. 11

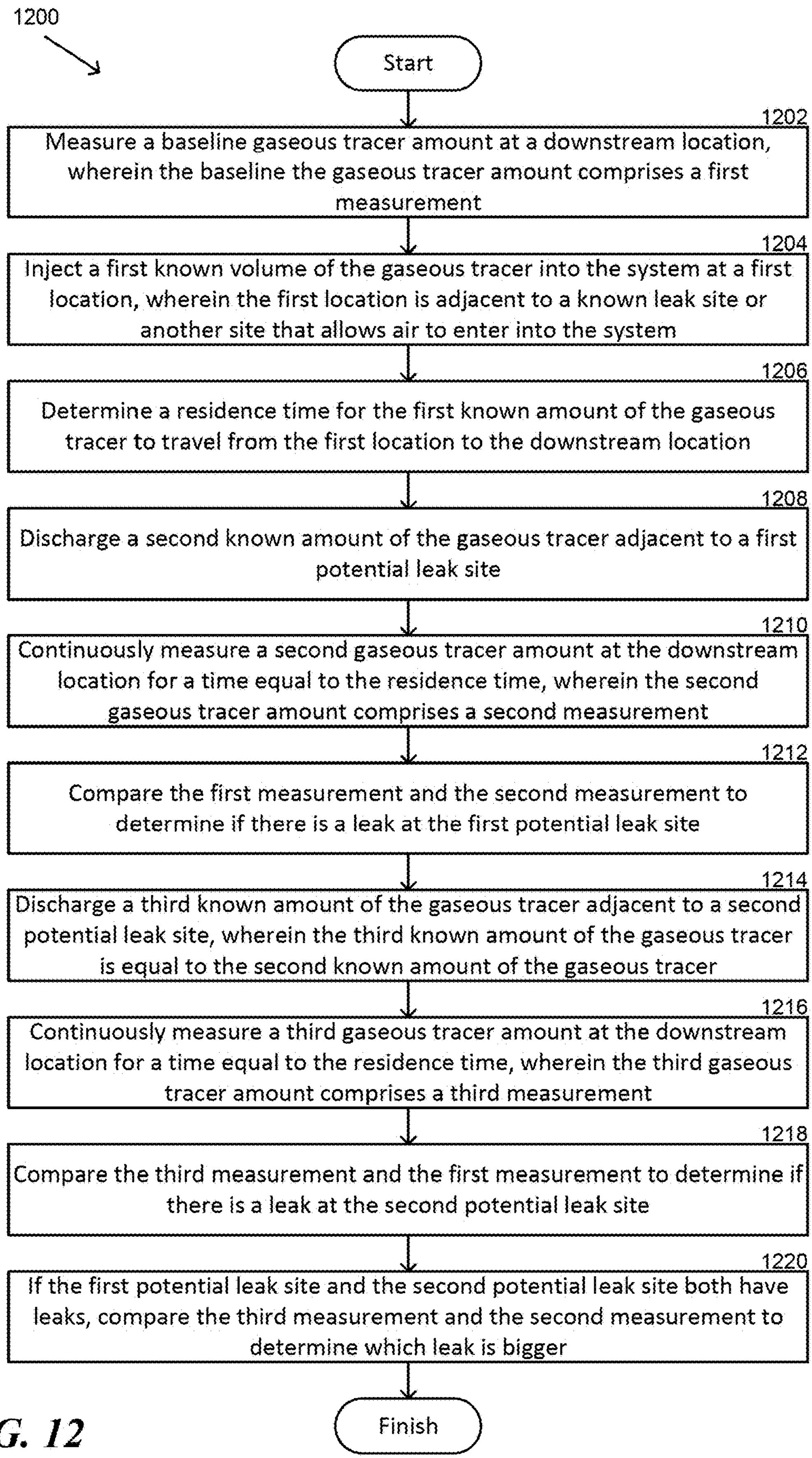

1200
Start
1202
Measure a baseline gaseous tracer amount at a downstream location, wherein the baseline the gaseous tracer amount comprises a first measurement
1204
Inject a first known volume of the gaseous tracer into the system at a first location, wherein the first location is adjacent to a known leak site or another site that allows air to enter into the system
1206
Determine a residence time for the first known amount of the gaseous tracer to travel from the first location to the downstream location
1208
Discharge a second known amount of the gaseous tracer adjacent to a first potential leak site
1210
Continuously measure a second gaseous tracer amount at the downstream location for a time equal to the residence time, wherein the second gaseous tracer amount comprises a second measurement
1212
Compare the first measurement and the second measurement to determine if there is a leak at the first potential leak site
1214
Discharge a third known amount of the gaseous tracer adjacent to a second potential leak site, wherein the third known amount of the gaseous tracer is equal to the second known amount of the gaseous tracer
1216
Continuously measure a third gaseous tracer amount at the downstream location for a time equal to the residence time, wherein the third gaseous tracer amount comprises a third measurement
1218
Compare the third measurement and the first measurement to determine if there is a leak at the second potential leak site
1220
If the first potential leak site and the second potential leak site both have leaks, compare the third measurement and the second measurement to determine which leak is bigger
Finish

FIG. 12

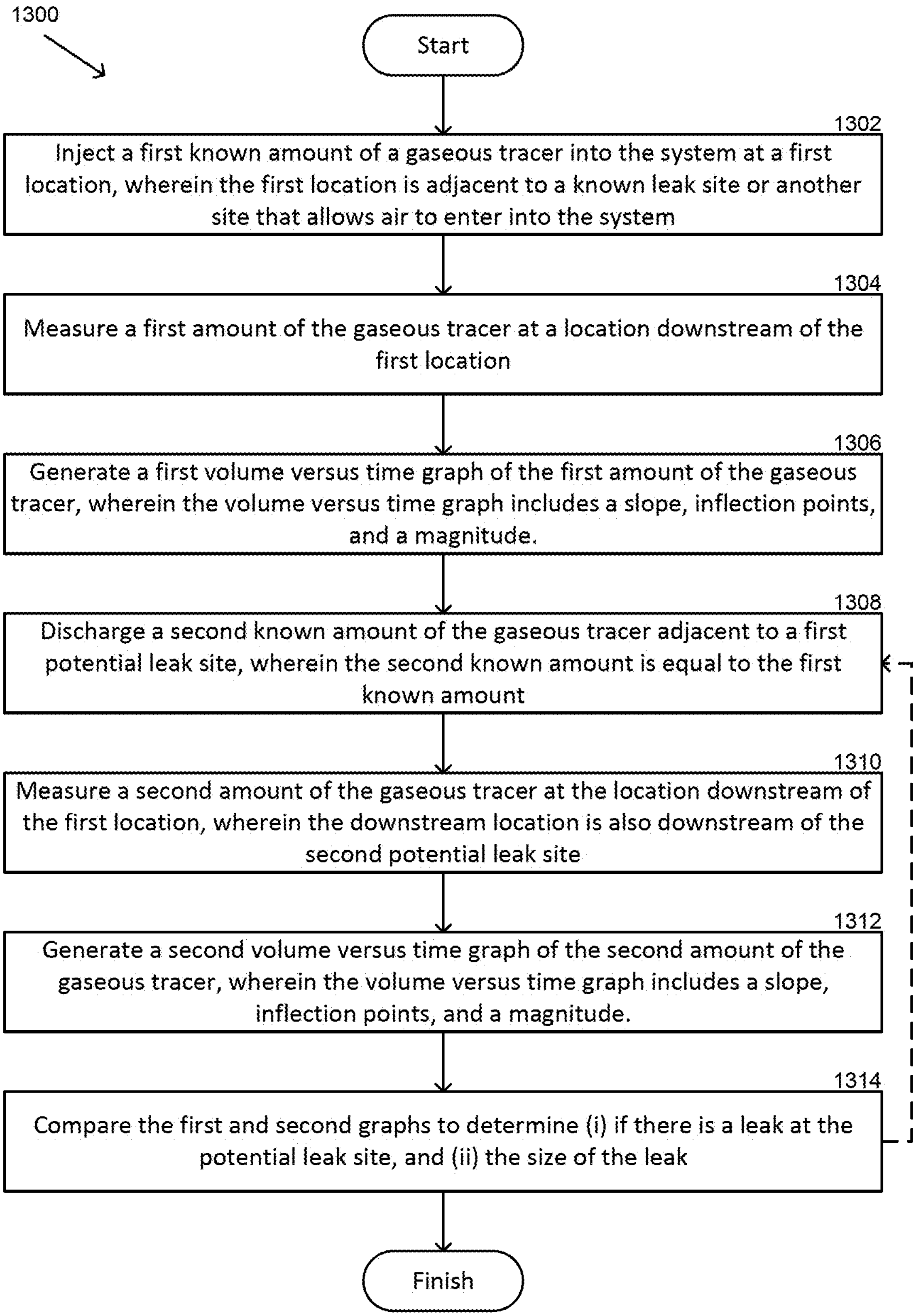

1300
Start
1302
Inject a first known amount of a gaseous tracer into the system at a first location, wherein the first location is adjacent to a known leak site or another site that allows air to enter into the system
1304
Measure a first amount of the gaseous tracer at a location downstream of the first location
1306
Generate a first volume versus time graph of the first amount of the gaseous tracer, wherein the volume versus time graph includes a slope, inflection points, and a magnitude.
1308
Discharge 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
1310
Measure 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
1312
Generate a second volume versus time graph of the second amount of the gaseous tracer, wherein the volume versus time graph includes a slope, inflection points, and a magnitude.
1314
Compare the first and second graphs to determine (i) if there is a leak at the potential leak site, and (ii) the size of the leak
Finish

FIG. 13

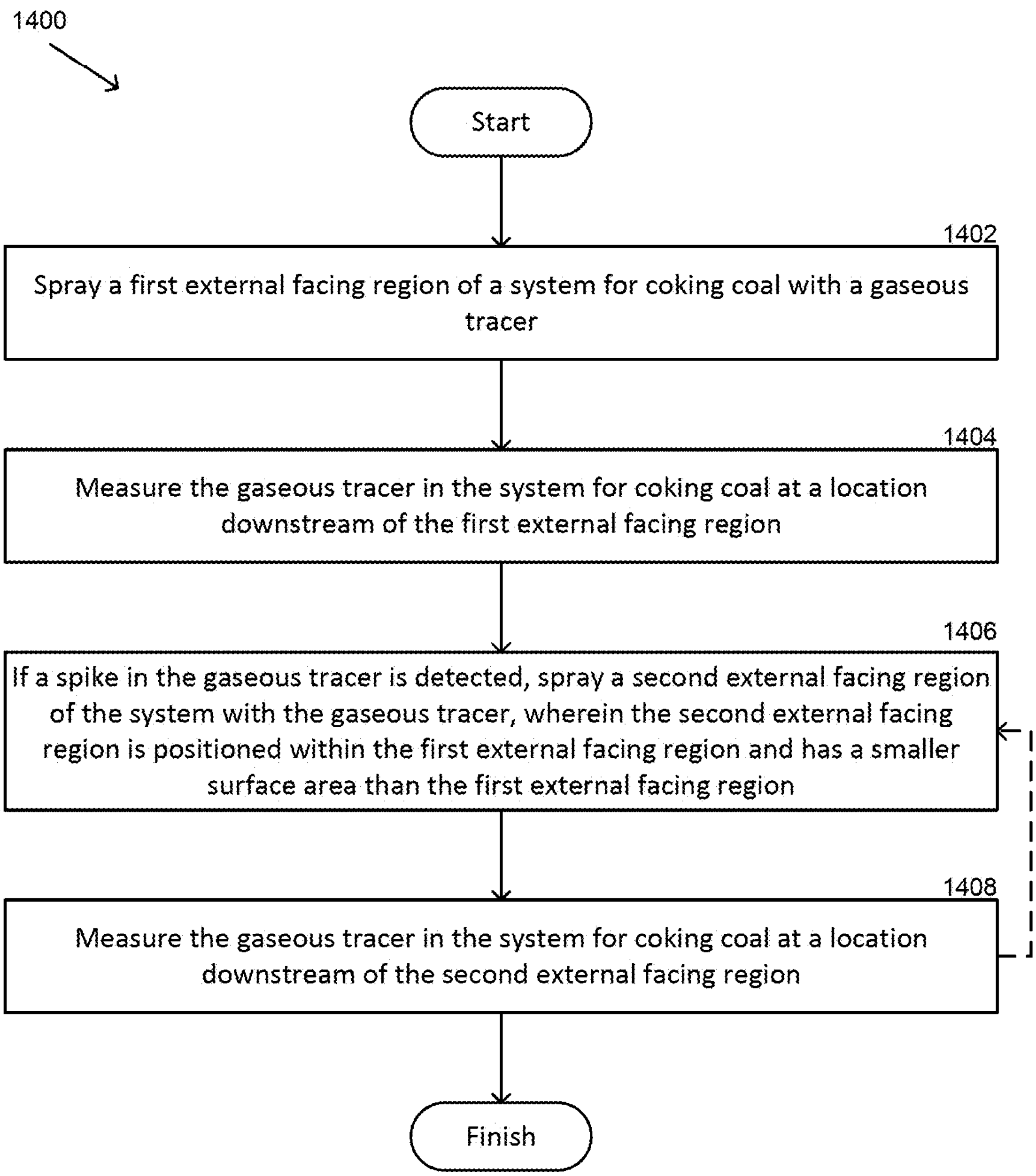

1400
Start
1402
Spray a first external facing region of a system for coking coal with a gaseous tracer
1404
Measure the gaseous tracer in the system for coking coal at a location downstream of the first external facing region
1406
If a spike in the gaseous tracer is detected, spray a second external facing region of the system with the gaseous tracer, wherein the second external facing region is positioned within the first external facing region and has a smaller surface area than the first external facing region
1408
Measure the gaseous tracer in the system for coking coal at a location downstream of the second external facing region
Finish

FIG. 14

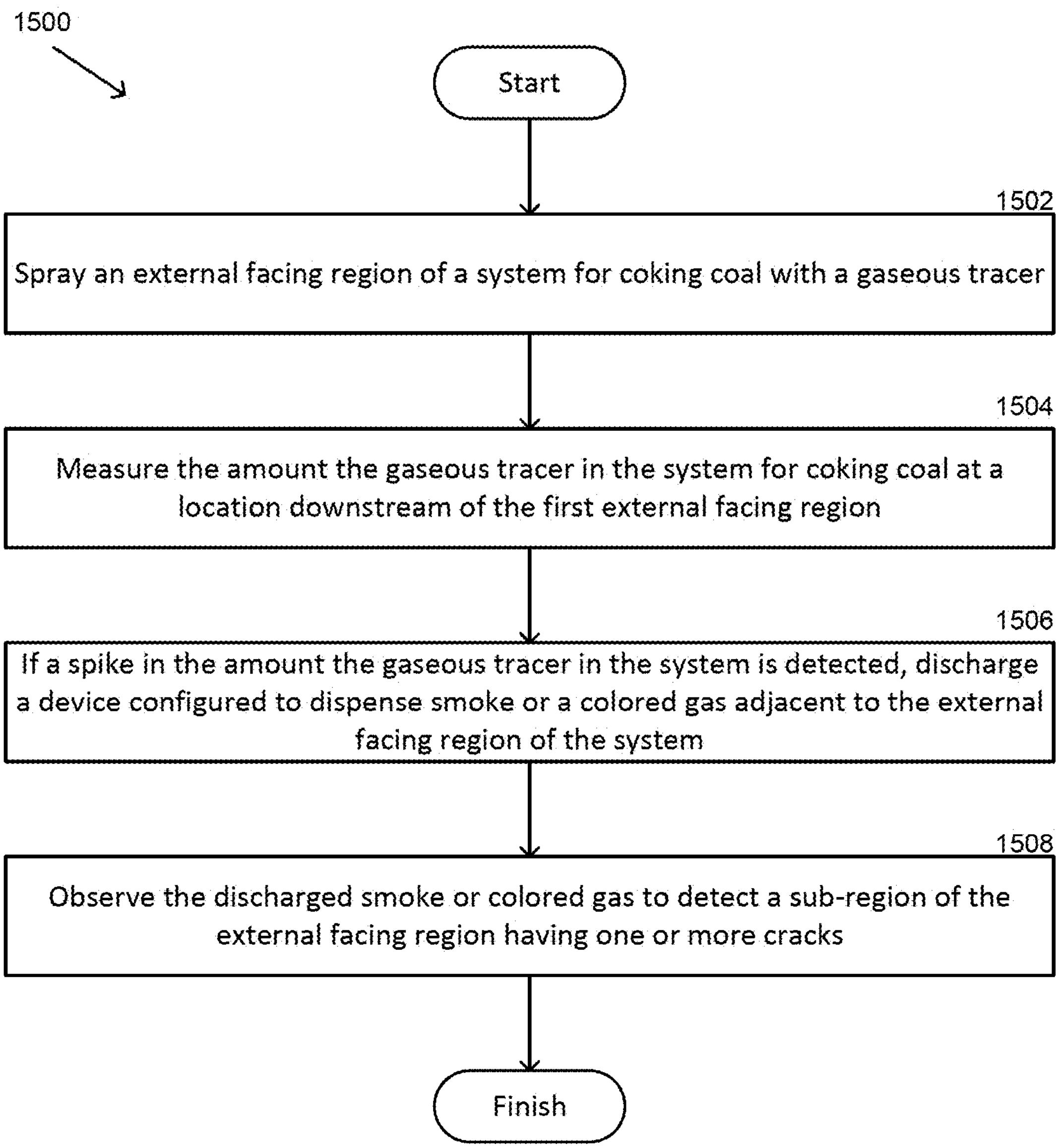

1500
Start
1502
Spray an external facing region of a system for coking coal with a gaseous tracer
1504
Measure the amount the gaseous tracer in the system for coking coal at a location downstream of the first external facing region
1506
If a spike in the amount the gaseous tracer in the system is detected, discharge a device configured to dispense smoke or a colored gas adjacent to the external facing region of the system
1508
Observe the discharged smoke or colored gas to detect a sub-region of the external facing region having one or more cracks
Finish

FIG. 15

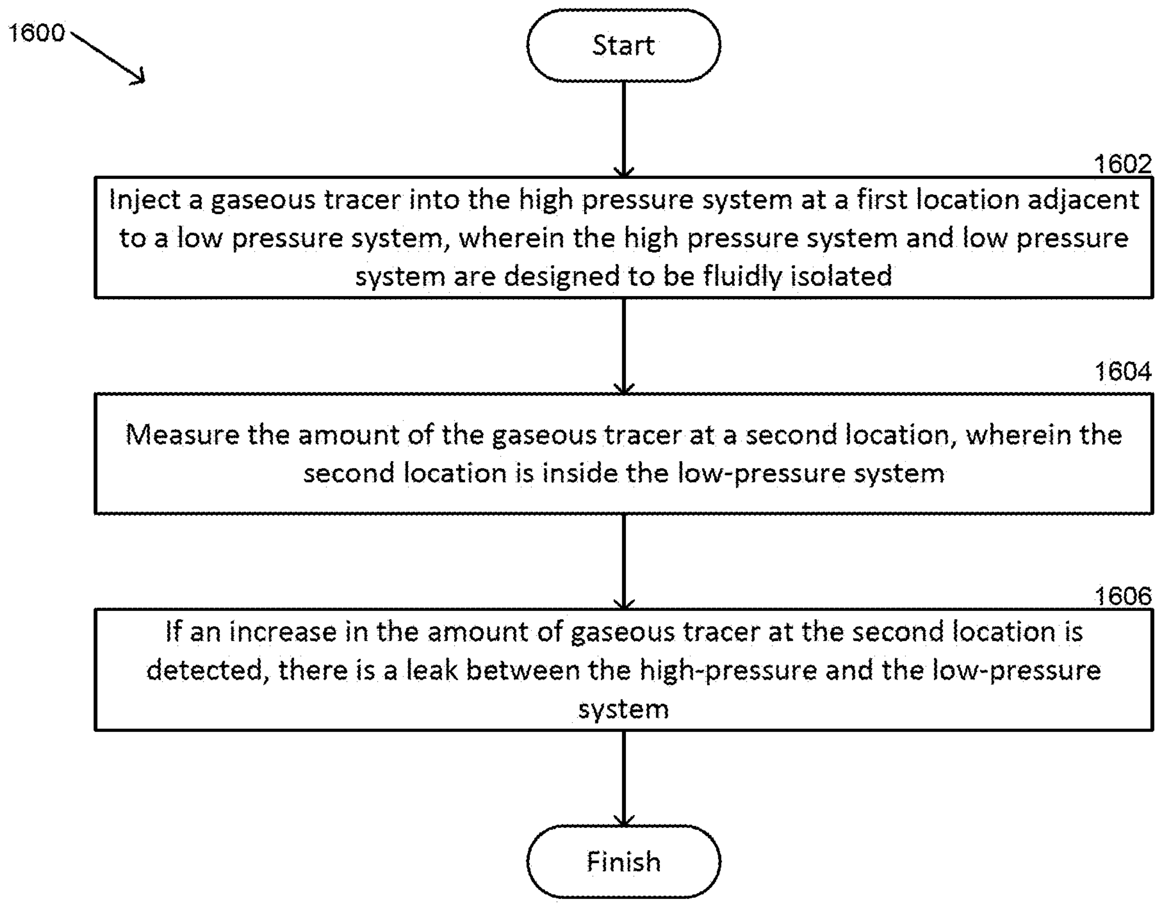

1600
Start
1602
Inject a gaseous tracer into the high pressure system at a first location adjacent to a low pressure system, wherein the high pressure system and low pressure system are designed to be fluidly isolated
1604
Measure the amount of the gaseous tracer at a second location, wherein the second location is inside the low-pressure system
1606
If an increase in the amount of gaseous tracer at the second location is detected, there is a leak between the high-pressure and the low-pressure system
Finish

FIG. 16

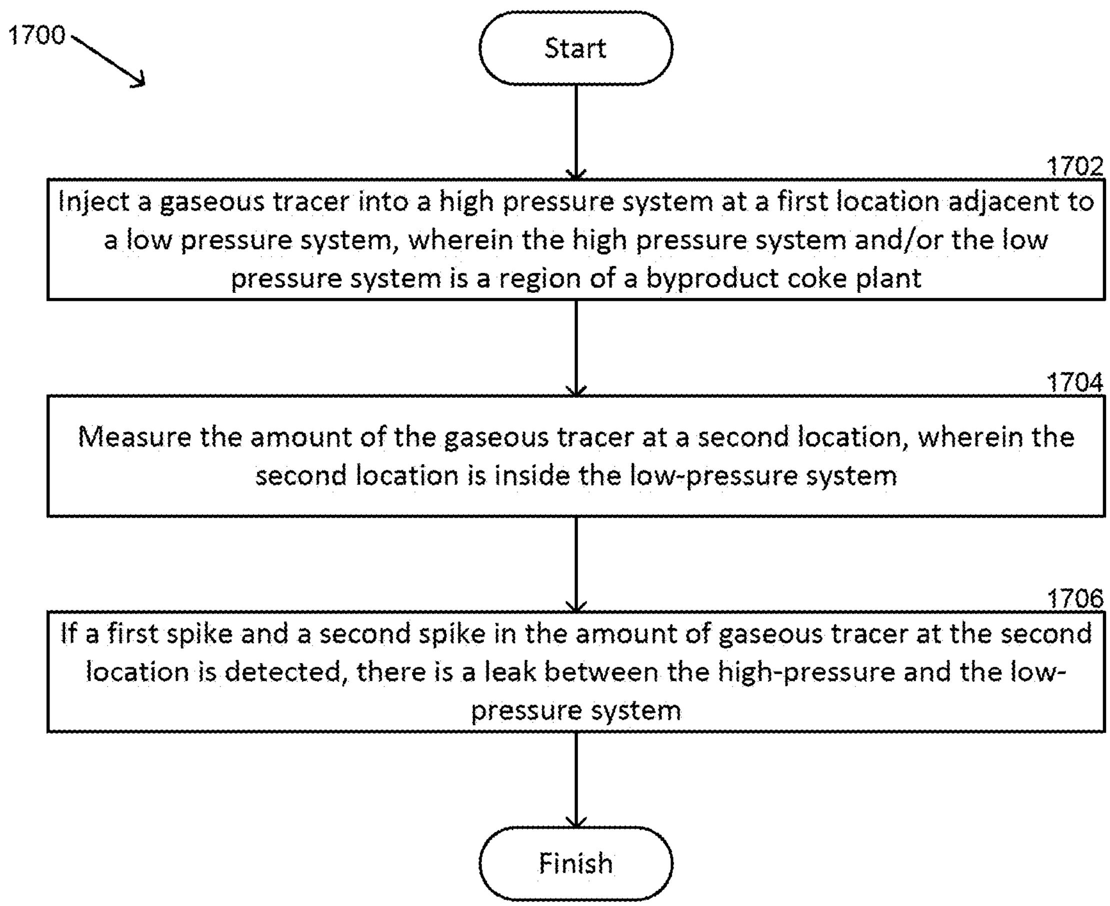
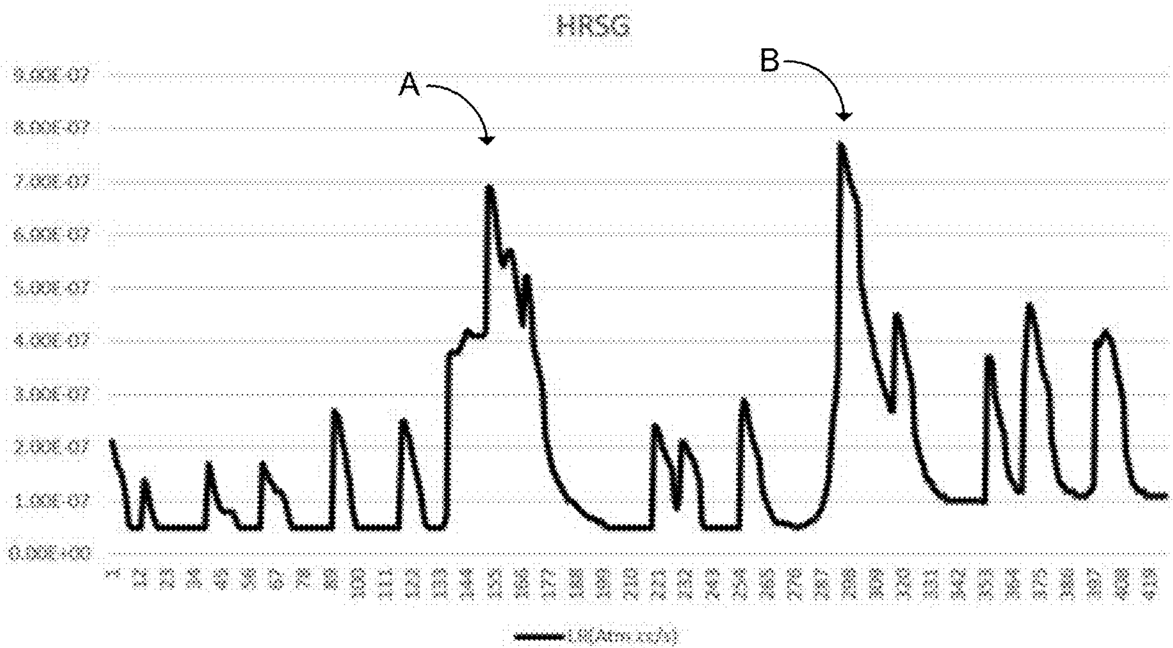

1700
Start
1702
Inject a gaseous tracer into a high pressure system at a first location adjacent to a low pressure system, wherein the high pressure system and/or the low pressure system is a region of a byproduct coke plant
1704
Measure the amount of the gaseous tracer at a second location, wherein the second location is inside the low-pressure system
1706
If a first spike and a second spike in the amount of gaseous tracer at the second location is detected, there is a leak between the high-pressure and the low-pressure system
Finish

FIG. 17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7.00E-07
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FIG. 18

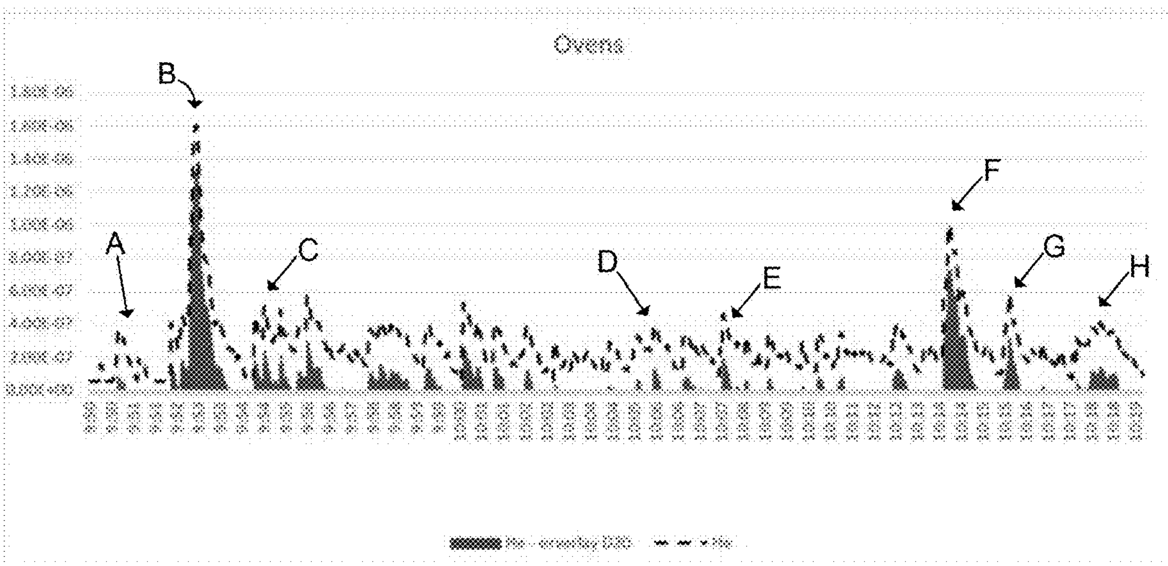

FIG. 19

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 Dec. 28, 2018; U.S. Provisional Patent Application No. 62/786,096, titled "SYSTEMS AND METHODS FOR TREATING A SURFACE OF A COKE PLANT," filed Dec. 28, 2018; U.S. Provisional Patent Application No. 62/786,157, titled "COKE PLANT TUNNEL REPAIR AND FLEXIBLE JOINTS," filed Dec. 28, 2018; and U.S. Provisional Patent Application No. 62/786,194, titled "COKE PLANT TUNNEL REPAIR AND ANCHOR DISTRIBUTION," filed Dec. 28, 2018; the disclosures of which are hereby incorporated by reference in their entireties.

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. **2**A 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. **2**B is a schematic illustration of a byproduct coke plant, including the byproduct coke oven battery illustrated in FIG. **2**A, 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 com busted 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. **2**A 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. **2**B. 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 contaminates 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. **2**B 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. **2**A, 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 **204** 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. **2**A 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 pant **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 **1100** further includes discharging a third known amount of gaseous tracer adjacent to a second potential leak site (process step **1114**). 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 **1100** 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 **1116**). Method **1100** continues by comparing the first measurement with the second measurement to determine if there is a second leak at the second potential leak site (process step **1118**). 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 **1100** continues by determining whether the first leak or the second leak is larger. To do so, the second measurement is compared with the first measurement (process step **1016**). 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 **1306** and **1308** 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 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.

I/We claim:

1. A method of detecting a leak in a system for coking coal, the method comprising:

discharging a gaseous tracer adjacent to a structure in the system for coking coal, wherein the structure at least partially divides a high-pressure system and a 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,

wherein measuring a spike in the amount of gaseous tracer at the location within and/or downstream from the low-pressure system indicates there is a leak in the structure.

2. The method of claim **1**, wherein the structure is configured to fluidly isolate the high-pressure system and the low-pressure system.

3. The method of claim **1**, wherein discharging the gaseous tracer adjacent to the structure comprises discharging the gaseous tracer in the high-pressure system.

4. The method of claim **1**, wherein the system for coking coal includes at least one oven and at least one sole flue chamber adjacent to the at least one oven, and wherein the at least one oven is the high pressure system, the at least one sole flue chamber is the low pressure system, and the structure divides the at least one oven and the at least one sole flue chamber.

5. The method of claim **1**, the system for coking coal includes at least one oven, at least one sole flue chamber adjacent to the at least one oven, and at least one tunnel, and wherein the high pressure system is an environment external to the at least one oven, the at least one sole flue chamber, and/or the at least one tunnel, and wherein the low pressure system is the at least one oven, the at least one sole flue chamber, or the at least one tunnel.

6. 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.

7. 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.

8. The method of claim **7**, wherein measuring a baseline amount of gaseous tracer further comprises zeroing a reading on a measuring device.

9. 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.

10. 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.

11. The method of claim **1**, wherein a Reynolds number defining the flow of the gaseous tracer is greater than 4,000 in at least one region of the system between the structure and the location.

12. 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.

13. 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.

14. The method of claim **12**, 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 the first external facing surface area.

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

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

17. The method of claim **1**, wherein the gaseous tracer is helium.

18. The method of claim **1**, wherein the structure includes insulation.

19. The method of claim **1**, wherein the steps of injecting and measuring are performed without shutting off operation of the system for coking coal.

20. The method of claim **1**, wherein a temperature of at least one of the high pressure or the low-pressure system is 1,000 degrees Celsius or higher during the steps of injecting and measuring.

21. A method of detecting an air leak in a system for coking coal, the method comprising:

injecting a first known amount of 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;

measuring a first test amount of the gaseous tracer at a location downstream of the first location;

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.

22. The method of claim **21**, 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.

23. The method of claim **22**, 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.

24. The method of claim **22** wherein the first magnitude corresponds to a first area under the curve and the second magnitude corresponds to a second area under the curve.

25. The method of claim **22**, 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.

26. The method of claim **21**, wherein injecting the first amount of the gaseous tracer into the system and discharging the second amount of the gaseous tracer adjacent to a 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.

27. The method of claim **21**, 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.

28. A method of detecting an air leak in a system for coking coal, the method comprising:

measuring a baseline amount of a gaseous tracer at a first location;

injecting a first amount of the gaseous tracer into the 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 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;

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.

29. The method of claim **28**, 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.

30. The method of claim **29**, 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.

31. The method of claim **30**, 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.

32. The method of claim **30**, 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.

33. The method of claim **30**, 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.

34. The method of claim **33**, 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.

35. The method of claim **28**, wherein the residence time is 120 seconds or less.

36. The method of claim **28**, 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.

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

spraying an external facing region of a system for coking coal with a gaseous tracer;

measuring an amount of the gaseous tracer in the system for coking coal at a location downstream from the first external facing region, wherein a spike in the amount of the gaseous tracer measured 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.

38. The method of claim **37**, wherein the device is a smoke generator or a smoke bomb.

39. 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:

injecting a gaseous tracer into the high-pressure system at a first location adjacent 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;

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.

40. The method of claim **39** wherein the low-pressure system is a heat recovery coke plant and the high-pressure system is an external environment surrounding the heat recovery coke plant.

41. The method of claim **39** wherein the high-pressure system and/or the low-pressure system is a region within a by-product coke plant.

42. The method of claim **39**, 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 at the potential leak site.

43. The method of claim **39**, further comprising:

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

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

44. The method of claim **39**, 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.

45. A method of detecting an air leak between a high-pressure system and a low-pressure system, the method comprising:

injecting a gaseous tracer into the high-pressure system at a first location adjacent to the low-pressure system; and

measuring the concentration of the gaseous tracer at a second location, wherein the second location is in the low-pressure system;

wherein detecting a first spike and a subsequent second spike temporally spaced apart from the first spike in the concentration of the gaseous tracer in the low-pressure system indicates there is a leak between the high-pressure system and the low-pressure system.

46. The method of claim **45**, wherein the high-pressure system and/or the low-pressure system is a region within a byproduct coke plant.

47. The method of claim **45** wherein the high-pressure system is a first region within a byproduct coke plant and the low-pressure system is a second region within the byproduct coke plant.

48. The method of claim **45**, 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.

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