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Huyck

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[54] **APPARATUS FOR, AND METHOD OF, OXIDIZING A GASEOUS MIXTURE CONTAINING A COMBUSTIBLE COMPONENT**

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[51] **Int. Cl.²** **F23D 13/20**

[58] **Field of Search** ..... 431/5, 202, 2; 23/277 C

[56] **References Cited**

UNITED STATES PATENTS

3,741,713	6/1973	Reed	431/202
3,817,687	6/1974	Cavallero et al.	431/202
3,837,785	9/1974	Evans et al.	431/5

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[57] **ABSTRACT**

Apparatus for oxidizing a gaseous mixture containing a potentially combustible component includes a combustion chamber for burning and oxidizing a combustible gas, a heated oxidation chamber for heating and oxidizing an incombustible gas, a conduit communicating a source of the gaseous mixture with the combustion and oxidation chambers, and electrically-operable gas valves arranged in the conduit and operable to deliver a flow of the gaseous mixture to either the combustion chamber or to the oxidation chamber. An electrical control circuit is adapted to sense the combustibility of the gaseous mixture. If such mixture is sensed to be incombustible, the control circuit operates the valves to deliver such flow to the oxidation chamber.

9 Claims, 2 Drawing Figures

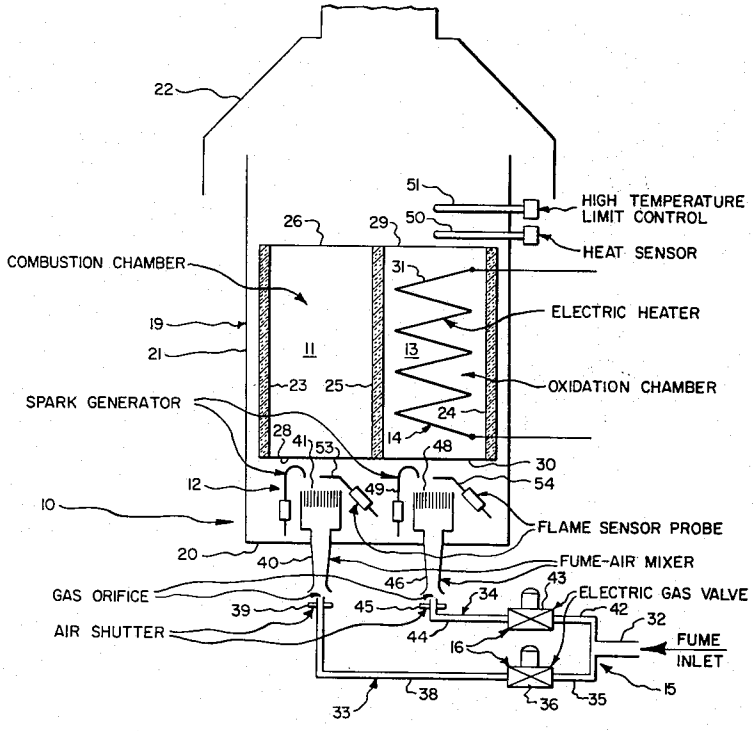


Fig. 1.

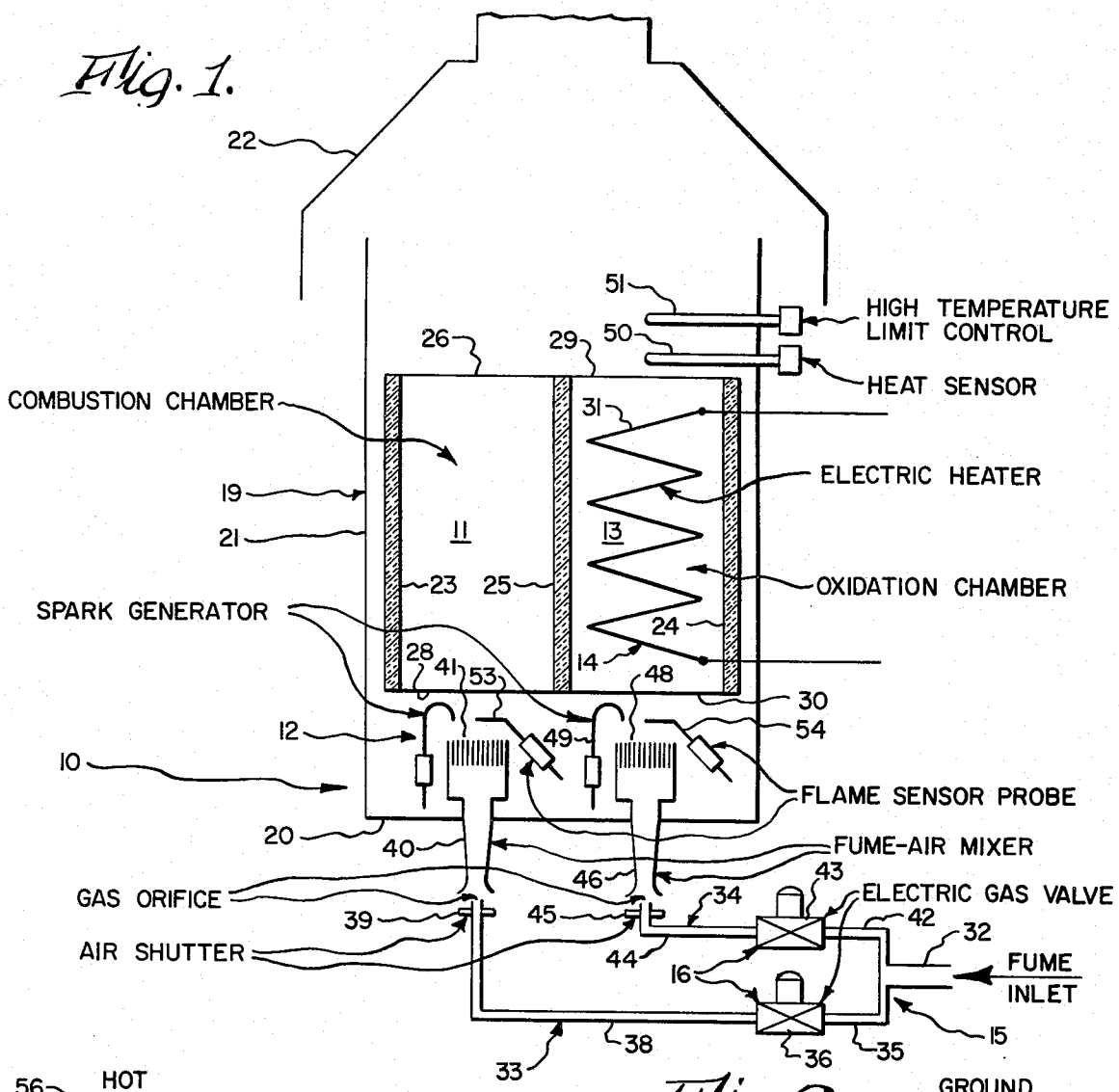
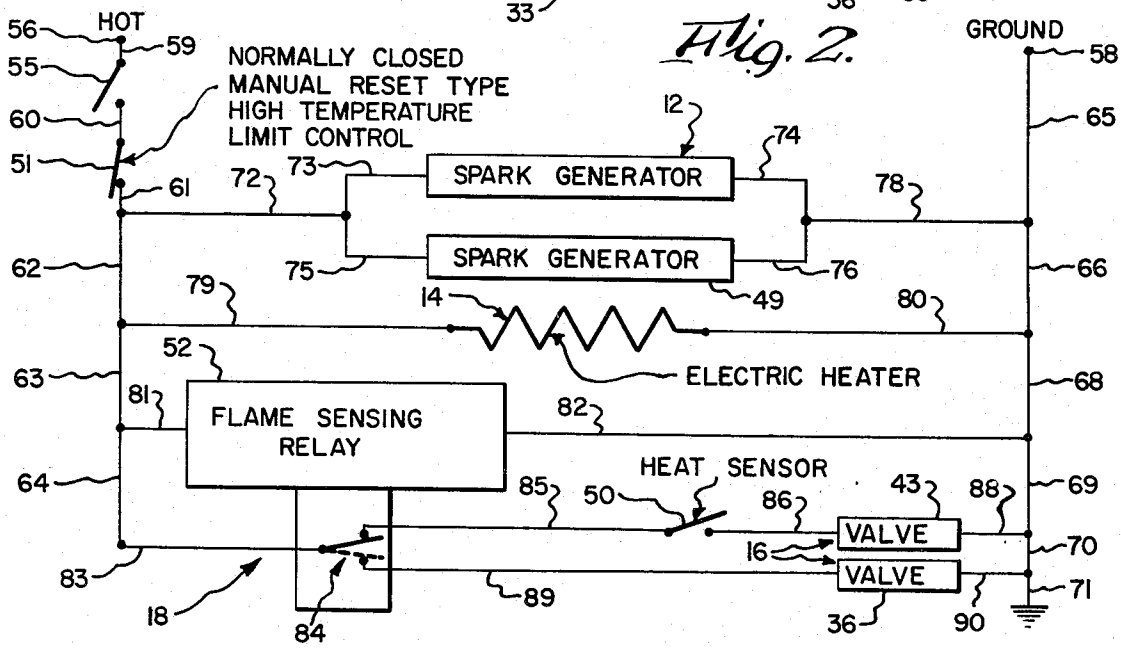

22
51
HIGH TEMPERATURE LIMIT CONTROL
26
29
50
HEAT SENSOR
COMBUSTION CHAMBER
31
ELECTRIC HEATER
19
21
11
13
OXIDATION CHAMBER
23
25
SPARK GENERATOR
24
28
41
53
14
48
30
12
54
49
10
FLAME SENSOR PROBE
20
40
FUME-AIR MIXER
46
43
GAS ORIFICE
34
ELECTRIC GAS VALVE
39
45
42
32
AIR SHUTTER
44
16
FUME INLET
38
36
35
15
33

Fig. 2.


56
HOT
59
55
NORMALLY CLOSED MANUAL RESET TYPE HIGH TEMPERATURE LIMIT CONTROL
60
51
61
72
73
SPARK GENERATOR
12
74
78
GROUND
58
65
62
75
SPARK GENERATOR
76
49
66
79
14
80
52
63
ELECTRIC HEATER
68
81
FLAME SENSING RELAY
82
64
HEAT SENSOR
85
50
86
43
88
69
VALVE
16
70
VALVE
83
89
71
18
84
36
90

APPARATUS FOR, AND METHOD OF, OXIDIZING A GASEOUS MIXTURE CONTAINING A COMBUSTIBLE COMPONENT

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates generally to apparatus for oxidizing a gaseous mixture containing a potentially combustible component.

2. Description of the Prior Art

Prior art efforts to provide apparatus for oxidizing a gaseous mixture have begun with the threshold inquiry of whether such mixture is combustible or incombustible.

The easiest way to oxidize a combustible gas is to ignite and burn it, as typically shown in Frey et al U.S. Pat. No. 3,697,229, Rosenberg et al U.S. Pat. No. 3,509,834, Chance U.S. Pat. No. 1,298,889, Kuhn U.S. Pat. No. 2,460,016, Stockman U.S. Pat. No. 3,353,919, and Wilson et al U.S. Pat. No. 3,337,455.

On the other hand, it is known that an incombustible gas may be oxidized by the influence of heat, this principle being shown in Shiller U.S. Pat. No. 3,404,965, Gerlach U.S. Pat. No. 3,279,168, Phillips U.S. Pat. No. 3,215,501, and Bloxham U.S. Pat. No. 3,190,823.

However, whether a particular gaseous mixture is combustible or incombustible may well depend upon the extent to which a potentially combustible component of the mixture is present with a cooperative amount of oxygen. For example, a particular gaseous mixture composed of gasoline fumes and air may be either combustible or incombustible, depending upon the relative proportional quantities to which these components are present in the mixture. Therefore, since the concentration of a potentially combustible component may vary with a number of factors, the combustibility of the entire mixture itself may vary.

SUMMARY OF THE INVENTION

The present invention provides apparatus for oxidizing a gaseous mixture containing a potentially combustible component, regardless of whether such mixture itself is combustible or incombustible. Moreover, the apparatus is particularly designed to oxidize a mixture of varying combustibility.

The apparatus broadly includes a combustion chamber having means for igniting a combustible gas; an oxidation chamber having means for heating and oxidizing an incombustible gas; conduit means communicatively connecting a source of the gaseous mixture with the combustion and oxidation chambers; valve means associated with the conduit means and operative to block the same to prevent a flow of the mixture therethrough, or to alternatively direct such flow to either the combustion chamber or to the oxidation chamber; and control means adapted to sense the combustibility of the mixture and to cause the valve means to permit and direct such flow to the combustion chamber when the mixture is sensed to be combustible, and to deliver such flow to the oxidation chamber when the mixture is sensed to be incombustible.

In one embodiment, the control means includes a first flame sensor operatively arranged to sense the presence of a flame in the combustion chamber and adapted to cause the valve means to divert such flow to the oxidation chamber when no flame is sensed in the combustion chamber.

The control means may further include igniting means, such as a spark generator, operatively arranged to attempt to ignite the mixture delivered to the oxidation chamber, and a second flame sensor operatively arranged to divert such flow to the combustion chamber when the presence of a flame is sensed in the oxidation chamber.

The control means may further include means for sensing the effective temperature of the oxidation chamber for causing the valve means to prevent such flow from entering the oxidation chamber when the temperature within the oxidation chamber is below a preselected minimum temperature.

The inventive apparatus oxidizes a gaseous mixture containing a potentially combustible component by supplying a flow of the mixture from a source thereof, sensing the combustibility of the supplied mixture, diverting the supplied flow to the combustion chamber if the mixture is sensed to be combustible, igniting the combustible mixture in the combustion chamber, diverting such supplied flow to a heated oxidation chamber if the mixture is sensed to be incombustible, and oxidizing such incombustible mixture in the oxidation chamber. In practicing this method, the combustibility of the mixture is preferrably sensed by determinging the presence or absence of a flame, or the heat thereof.

One object of the present invention is to provide improved apparatus for oxidizing a gaseous mixture containing a potentially combustible component.

Another object is to provide improved apparatus for oxidizing either a combustible or an incombustible gaseous mixture.

Another object is to provide improved oxidation apparatus wherein the combustibility of a supplied gaseous mixture is sensed.

Another object is to provide improved apparatus for, and a method of, oxidizing a gaseous mixture wherein the mixture is oxidized by burning in a combustion chamber if such mixture is sensed to be combustible, and oxidized in a heated oxidation chamber if such mixture is sensed to be incombustible.

Still another object is to provide improved apparatus capable of oxidizing a gaseous mixture regardless of the combustibility of the mixture.

These and other objects and advantages will become apparent from the foregoing and ongoing specification which includes the drawings and the appended claims.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a mechanical schematic view of the structure of the apparatus, principally illustrating the combustion and oxidation chambers, the conduit arranged to deliver a flow of the gaseous mixture to the combustion and oxidation chambers, the valves associated with the branch conduits, and the location of the flame sensor probes, the heat sensor switch, and the high temperature limit control switch.

FIG. 2 is an electical schematic view of the circuitry of the invention, illustrating the arrangement of the spark generators, the electric heater, and further showing the flame sensing relay arranged to control operation of the valves.

DESCRIPTION OF THE PREFERRED EMBODIMENT

At the outset, it should be clearly understood that like reference numerals are intended to identify the same elements and/or structure throughout the several drawing figures, as such elements and/or structure may be further described or explained by the entire written specification of which this detailed description is an integral part.

Referring initially to FIG. 1, the present invention provides apparatus, generally indicated at **10**, for oxidizing a gaseous mixture containing a potentially combustible component, such as gasoline fumes, and flowing from a source (not shown) thereof.

As used herein, a "potentially combustible component" is intended broadly to refer to any gaseous fluid which, when mixed with the proper amount of oxygen, is capable of burning when ignited. However, since such potentially combustible components may be present in gaseous mixtures in varying fractional degrees, it should be clearly understood that combustibility of such mixtures, as a whole, may vary. Hence, some mixtures may be combustible, while others may be incombustible.

The apparatus **10** broadly includes a combustion chamber **11** having means, generally indicated indicated at **12**, for igniting a flow of combustible gas delivered to the combustion chamber; an oxidation chamber **13** having means, generally indicated at **14**, for heating and oxidizing a flow of incombustible gas rising through the oxidation chamber; conduit means **15** communicatively connecting a source (not shown) of the gaseous mixture with the combustion chamber **11** and with the oxidation chamber **13**; valve means, generally indicated at **16**, associated with the conduit means **15** and operative to selectively block and prevent a flow of the gaseous mixture through the conduit means, or to alternatively permit and divert such flow to either the combustion chamber **11** or to the oxidation chamber **13**; and control means, generally indicated at **18** in FIG. **2**, adapted to sense the combustibility of the gaseous mixture flowing through the conduit means **15** and to cause the valve means **16** to direct such flow to the combustion chamber **11** when such mixture is sensed to be combustible, and to divert such flow to the oxidation chamber **13** when such mixture is sensed to be incombustible.

Adverting now to FIG. 1, the combustion and oxidation chambers **11, 13** are schematically depicted as contained within an enclosure **19** having a horizontal bottom **20**, and a vertical side wall structure **21** rising upwardly therefrom. Side wall structure **21** is shown provided with an open upper end suitably covered by an overhead inverted hopper-like hood structure **22** which functions to direct or funnel the rising flow of gaseous products of combustion and oxidation, such as carbon dioxide (CO_2) and water vapor, (H_2O), upwardly away from the combustion and oxidation chambers **11, 13** and from enclosure **19**.

Arranged within this enclosure **19**, the combustion and oxidation chambers **11, 13** are depicted as bounded by a pair of laterally-adjacent left and right open-ended vertical tubes **23, 24** respectively, sharing an intermediate common wall **25**. The leftward tube **23**, bounding the combustion chamber **11**, is specifically shown as having upper and lower open ends **26, 28**, respectively. Similarly, the rightward tube **24**, bounding the oxidation chamber **13** is also shown as having upper and lower open ends **29, 30**, respectively. If desired, the vertical tubular walls **23, 24** and **25** may be made of a suitable thermal insulating or refractory material, as depicted in FIG. **1**.

In the presently preferred embodiment herein disclosed, the means **14** for heating and oxidizing a gas delivered to the oxidation chamber is schematically shown as including an electrical resistance-type heating element **31** suitably mounted within right tube **24** to heat the oxidation chamber. When energized, this heating element **31** operates to elevate the temperature of a gas rising through oxidation tube **24** to oxidize such rising gas and to reduce hydrocarbons therein to carbon dioxide (CO_2) and water vapor (H_2O).

The conduit means **15** is shown as including a main supply conduit **32** communicating the source (not shown) of the gaseous mixture with a first branch conduit **33** leading to the combustion chamber **11**, and with a second branch conduit **34** leading to the oxidation chamber **13**. The first branch conduit **33** includes, in series, pipe conduit **35** communicating with supply conduit **32**, electrically-operable gas valve **36**, pipe conduit **38**, air shutter **39**, and gas burner **40** mounted to penetrate the enclosure bottom **20** and having an uppermost perforated burner head **41** arranged beneath the combustion chamber **11**. Similarly, the second branch conduit **34** includes, in series, pipe conduit **42** communicating with supply conduit **32** electrically-operable gas valve **43**, pipe conduit **44**, air shutter **45**, and gas burner **46** mounted to penetrate the enclosure bottom **20** and having an uppermost perforated burner head **48** arranged beneath the oxidation chamber **13**. Thus, the conduit means **15**, which includes the first and second branch conduits, **33, 34**, respectively, communicatively connects the source (not shown) of the mixture with the combustion chamber **11** and with the oxidatin chamber **13**.

In the presently preferred embodiment, the means **12** for igniting a combustible gas is shown as being a conventional spark generator operatively arranged between burner head **41** and the lower open end **28** of combustion chamber **11** to attempt to ignite gas rising upwardly from burner head **41**.

The valve means **16** includes electrically-operated gas valves **36, 43**, arranged in the first and second branch conduits **33, 34**, respectively. Each of valves **36, 43** may be selectively operated by the control means **18** to block its associated branch conduit to prevent the gaseous mixture from flowing from the source (not shown) to its serviced burner, or to alternatively unblock its associated branch conduit to enable such flow. Hence, if valve **36** is opened and valve **43** is closed, the gaseous mixture will be permitted to flow from the source through the main supply conduit **32** and the first branch conduit **33** to the combustion chamber **11**. Conversely, if valve **36** is closed and valve **43** is opened, the gaseous mixture will be permitted to flow from the source through the main supply conduit **32** and the second branch conduit **34** to the oxidation chamber **13**. Thus, by selectively closing one of these valves and opening the other, the valve means **16** functions to permit and direct such flow to either the combustion chamber or to the oxidation chamber. Obviously, if gas valves **36, 43** are both closed, the conduit means **15** will be blocked to prevent such flow to either

the combustion chamber **11** or the oxidation chamber **13.** It should be clearly understood that in lieu of providing a separate valve in each branch conduit, a single three-way valve, capable of performing the same functions as valves **36, 43** may be arranged at the juncture of the main supply conduit **32** with the first and second branch conduits, **33, 34,** respectively.

Referring now conjunctively to FIGS. **1** and **2,** the control means **18** broadly includes igniting means, such as spark generator **49,** arranged between the oxidation chamber lower end **30** and burner head **48,** heat sensor switch **50** and high temperature limit control switch **51** mounted on enclosure side wall **21** and operatively arranged above the oxidation chamber **13,** and a flame sensing relay **52** having flame sensor probes **53, 54** arranged above the combustion chamber burner head **41** and the oxidation chamber burner head **48,** respectively (FIG. **1**).

Adverting now to FIG. **2,** the electrical circuitry of the apparatus is schematically depicted as broadly including manual "on-off" switch **55**; high temperature limit control switch **51**; spark generators **12, 49**; electrical heater **14**; flame sensing relay **52**; heat sensor switch **50**; and electrically-operable gas valves **36, 43.**

An input voltage applied across circuit input terminals **56, 58** will produce a like potential between a hot wire connected to circuit terminal **56,** and a ground wire connected to circuit terminal **58.** This hot wire includes, in series: conductor **59** connected to circuit input terminal **56**; manual switch **55** when in the closed position; conductor **60**; normally closed (N/C) high temperature limit control switch **51,** and conductors **61, 62, 63** and **64.** The ground wire includes, in series: conductor **65** connected to circuit input terminal **58,** conductors **66, 68, 69** and **70,** and grounded conductor **71.**

When switches **55** and **51** are both closed, current may flow through a plurality of parallel circuits severally connected to the hot wire and to the ground wire. Specifically, current may flow from hot wire conductor **61** through a first parallel circuit containing conductor **72**; a first branch circuit containing, in series, conductor **73,** spark generator **12,** and conductor **74**; a second branch circuit arranged in parallel with the first branch circuit and including, in series, conductor **75,** spark generator **49,** and conductor **76**; and conductor **78** connected to ground wire conductor **65.**

Current may also flow from hot wire conductor **62** through a second parallel circuit containing, in series, conductor **79,** resistance heater **14,** and conductor **80** connected to ground wire conductor **66.**

Current may also flow from hot wire conductor **63** through a third parallel circuit containing, in series, conductor **81,** flame sensing relay **52,** and conductor **82** connected to ground wire conductor **68.**

Current may also flow from hot wire conductor **64** through a fourth parallel circuit containing, in series, conductor **83**; flame sensor controlled switch **84**; a third branch circuit including, in series, conductor **85,** heat sensor switch **50** when closed, conductor **86,** solenoid valve **43,** and conductor **88** connected to ground wire conductor **69**; and a fourth branch circuit arranged in parallel with the third branch circuit and including, in series, conductor **89,** solenoid valve **36,** and conductor **90** connected to ground wire conductor **70.**

OPERATION

To operate the apparatus **10** from a deactivated condition, manual switch **55** must first be closed to energize the several parallel circuits. When this switch has been closed, current may flow from the hot wire to the ground wire through spark generators **12, 49**; electric heater **14**; and flame sensing relay **52.** However, since a "no flame" condition will be initially sensed in the combustion chamber by flame sensor probe **53,** relay **52** will cause switch **84** to move to the position shown in solid in FIG. **2,** thereby attempting to operate valve **43** to deliver a flow of the gaseous mixture to the oxidation chamber **13.**

Heat sensor switch **50** determines when resistance heater **14** has heated the oxidation chamber **13** to its preselected operating temperature capable of oxidizing the gaseous mixture, and thereafter closes to complete the circuit including valve **43** to operate this valve and enable a flow of the gaseous mixture to the oxidation chamber **13** through the second branch conduit **34.**

When such flow of the gaseous mixture in second branch conduit **34** passes upwardly through burner head **48,** spark generator **49** attempts to ignite the mixture. If the mixture is incombustible, such mixture will not be ignited and a no flame condition in the oxidation chamber **13** will be sensed by flame sensor probe **54.** This condition is transmitted via flame sensing relay **52** to maintain switch **84** in its present position, allowing a continued flow of the incombustible gaseous mixture to pass through the second branch conduit and rise upwardly through burner head **48** to the oxidation chamber. During its ascent through the heated oxidation chamber, this incombustible gaseous mixture is oxidized under the influence of heat supplied by heater **14.**

Should the gaseous mixture delivered to the oxidation chamber become combustible, spark generator **49** will ignite the mixture and flame sensing probe **54** will then sense a "flame" condition in the oxidation chamber. Should this occur, flame sensing relay **52** will cause switch **84** to move to the phantom position depicted in FIG. **2,** thereby deenergizing and closing valve **43** to block the first branch conduit **34,** and energizing and opening valve **36.** When valve **36** has opened, the gaseous mixture will be permitted to flow from the source thereof through the first branch conduit **33** to the combustion chamber **11** wherein such combustible gaseous mixture rising through burner head **41** will be ignited by spark generator **12.** This combustible gas will be continuously supplied to the combustion chamber as long as flame sensor probe **53** senses the presence of a flame in the combustion chamber.

Should the gaseous mixture then become incombustible, a no flame condition will be sensed by flame sensor probe **53.** When this occurs, flame sensing relay **52** will cause switch **84** to revert to the solid position depicted in FIG. **2,** thereby deenergizing and closing valve **36,** and energizing and opening valve **43** to divert the flow of the gaseous mixture from the combustion chamber to the oxidation chamber.

The normally-closed high temperature limit control switch **51** is provided as an additional safety feature. Should the temperature in oxidation chamber **13** exceed a preselected maximum temperature, as by sustained combustion of the gaseous mixture in the oxidation chamber, switch **51** will automatically open to disconnect the electrical circuit of the apparatus from the

input terminal **56**, thereby deenergizing the apparatus and closing valves **36, 43.**

In this manner, the inventive apparatus **10** operates to sense or determine the combustibility of the gaseous mixture flowing through the conduit means, and to deliver such flow to the oxidation chamber if such mixture is sensed to be incombustible, and to deliver such mixture to the combustion chamber if such mixture is sensed to be combustible. It will be noted by those skilled in this art that after the oxidation chamber has been heated to its operating temperature, the control means will automatically divert the flow of the gaseous mixture to either the combustion chamber or the oxidation chamber in response to the sensed combustibility of the mixture.

The several mechanical and electrical components of the inventive apparatus are well known to those skilled in this art and need not be specifically described. However, it is contemplated that spark generators **12, 49** may operate either continuously or intermittently, as desired.

While a preferred embodiment of the present invention has been shown and described herein, it will be understood by those skilled in this art that various changes and modifications may be made without departing from the spirit of the invention which is defined by the following claims.

What is claimed is:

1. Apparatus for oxidizing a gaseous mixture containing a potentially combustible component and flowing from a source thereof, comprising:

a combustion chamber having means for igniting a combustible gas delivered thereto;

an oxidation chamber having means for heating and oxidizing a gas delivered thereto;

conduit means communicatively connecting said source with said combustion and oxidation chambers;

valve means associated with said conduit means and operative to block said conduit means to prevent said flow and to permit and direct said flow to either said combustion chamber or to said oxidation chamber;

control means adapted to sense the combustibility of said mixture and to cause said valve means to direct said flow to said combustion chamber when said mixture is sensed to be combustible, and to deliver said flow to said oxidation chamber when said mixture is sensed to be incombustible.

2. The apparatus according to claim **1** wherein said control means includes a first flame sensor operatively arranged to sense the presence of a flame in said combustion chamber for causing said valve means to divert said flow to said oxidation chamber when no flame is sensed in said combustion chamber.

3. The apparatus according to claim **1** wherein said control means includes igniting means operatively arranged to attempt to ignite said mixture delivered to said oxidation chamber, and a second flame sensor operatively arranged to cause said valve means to direct said flow to said combustion chamber when a flame is sensed in said oxidation chamber.

4. The apparatus according to claim **1** wherein said control means includes a first flame sensor operatively arranged to sense the presence of a flame in said combustion chamber for causing said valve means to divert said flow to said oxidation chamber when no flame is sensed in said combustion chamber, igniting means operatively arranged to attempt to ignite said mixture delivered to said oxidation chamber, and a second flame sensor operatively arranged for causing said valve means to direct said flow to said combustion chamber when a flame is sensed in said oxidation chamber.

5. The apparatus according to claim **1** wherein said control means further includes a temperature switch for sensing the temperature of said oxidation chamber and for causing said valve means to prevent said flow from entering said oxidation chamber when the temperature of said oxidation chamber is below a preselected minimum temperature.

6. The apparatus according to claim **4** wherein said control means further includes a temperature switch for sensing the temperature of said oxidation chamber and for causing said valve means to prevent said flow from entering said oxidation chamber when the temperature of said oxidation chamber is below a preselected minimum temperature.

7. The method of oxidizing a gaseous mixture containing a combustible component, comprising the steps of:

supplying a flow of said mixture from a source thereof;

sensing the combustibility of such supplied mixture;

delivering such supplied flow to a combustion chamber if said mixture is sensed to be combustible;

igniting and burning such mixture in said combustion chamber;

delivering such supplied flow to heated oxidation chamber if said mixture is sensed to be incombustible; and

oxidizing such incombustible mixture in said oxidation chamber.

8. The method according to claim **7** wherein the step of sensing the combustibility of such supplied mixture, includes the further steps of:

attempting to ignite said mixture; and

determining the presence of a flame produced by such ignited mixture.

9. The method according to claim **7** wherein the step of delivering such supplied flow to an oxidation chamber if said mixture is sensed to be incombustible includes the further step of:

admitting said incombustible mixture to said oxidation chamber only when the temperature of said oxidation chamber exceeds a preselected minimum temperature.

* * * * *