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(54) **Apparatus and method for burning combustible gases**

Vorrichtung und Verfahren zum Brennen von brennbaren Gasen

Dispositif et procédé pour brûler des gaz combustibles

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(72) Inventor: **Swithenbank, Joshua**
Hathersage, Sheffield S30 1AE (GB)

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(74) Representative: **Attfield, Donald James et al**
Barker Brettell
138 Hagley Road
Edgbaston
Birmingham B16 9PW (GB)

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GB-A- 1 193 820 **GB-A- 1 249 967**
US-A- 3 893 810

(73) Proprietor: **CABOT CORPORATION**
Boston, Massachusetts 02210-2019 (US)

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Description

FIELD OF THE INVENTION:

5 **[0001]** The present invention relates to an apparatus for burning combustible gas and a method for using the apparatus.

BACKGROUND:

10 **[0002]** Gases containing common air pollutants, such as hydrocarbons, alcohols, ethers, soot and other combustibles, are frequently encountered in industries wherein combustion furnaces are utilized. In order to reduce the emission of pollutants and waste smoke into the atmosphere, a variety of devices have been proposed for burning the combustible gases.

15 **[0003]** A commonly utilized device is referred to as a flare stack wherein combustible gas is burned and discharged into the open air. Several exemplary prior art techniques are disclosed in the following patents.

[0004] U.S. Patent No. 3,828,700 to Ragot discloses an apparatus and process for the smokeless burning of residues. The apparatus consists of a chimney designed for the introduction of air into the burning zone, and a mechanism for introducing the residue into the chimney in the form of a spray. Thus the disclosed apparatus and process require that the residues to be burned off be pulverized or otherwise converted to a spray before introduction into the chimney.

20 **[0005]** U.S. Patent No. 3,852,023 to Itoh et al. discloses an apparatus for disposing of gas by burning. The apparatus consists of a plurality of branch pipes connected to a main pipe carrying combustible gas. The gas is channeled into one or more of the branch pipes according to the flow rate in the main pipe. The branch pipes are connected to a combustion furnace having a plurality of stages arranged in vertical order, gas introduced into the combustion furnace through the branch pipes is ignited and burned by ignition means located in the lowermost stage of the furnace.

25 **[0006]** U.S. Patent No. 3,898,317 to Hemsath et al. discloses an incineration system for incinerating flue gases which contain a combustible component. The system uses two chambers that are added to a stack emitting industrial gases. The first chamber terminates at the exit end of the stack in an annular passage so that high velocity air, which acts as an air pump, is directed longitudinally relative to the stack. The second chamber is disposed downstream of the first chamber and includes a plurality of burners and a thermocouple that senses the temperature of the gases. A preset temperature is achieved in the chambers by varying the quantities of air emitted from the first chamber as well as the amount of fuel and air supplied to the burners in the second chamber.

[0007] U.S. Patent No. 3,954,386 discloses a flare burner for burning combustible gases. The flare burner consists of a venturi burner tube having specified dimensions, a gas supply pipe having a gas outlet opening at the throat of the venturi burner tube and pilot burner jets for burning combustion gases.

35 **[0008]** U.S. Patent No. 4,003,693 discloses a flare stack gas burner consisting of a stack with a centrally disposed combustible gas delivery pipe having a divider with arms for upward delivery of the combustible gas through a plurality of slots to a mixing space. The flare stack also includes a rotary diffuser for mixing the combustible gas with air which is introduced under pressure into the stack.

[0009] Document US-A-3 893 810 discloses an apparatus and a method for burning the combustible components of a gas stream according to the preamble of claims 1 and 3 respectively.

40 **[0010]** It is an object of the present invention to provide a method and apparatus for burning the combustible components of gases with the advantages which will become apparent from the following discussion.

SUMMARY OF THE INVENTION:

45 **[0011]** The present invention relates to a method and apparatus for burning the combustible components of gases produced in industrial processes. The method and apparatus are particularly well suited for use in burning the combustible components of the gas stream exiting from a carbon black furnace during the production of carbon blacks.

[0012] The apparatus of the present invention is defined in claim 1.

50 **[0013]** The method of the present invention is defined in claim 3. The method of the present invention is preferably performed using the apparatus of the present invention.

[0014] The gas supply pipe refers to the pipe or conduit emitting gases produced in an industrial process. The gas stream flows from the supply pipe into one end of the stack pipe. In the case of a carbon black furnace reactor, the gas supply pipe emits the gas stream resulting from the production of carbon black. The communication between the gas supply pipe and the end of the stack pipe in the apparatus of the present invention should be sufficient to minimize the possibility of gas escaping into the atmosphere at, or near, the position where the supply pipe and the stack pipe are in communication. As explained below, the gas supply pipe and the stack pipe can overlap.

55 **[0015]** The means for introducing air may be any means known to the art. The amount of air introduced should be

sufficient to produce an ignitable mixture of air and gas. Such determination is within the skill of those of ordinary skill in the art. In a preferred embodiment of the apparatus of the present invention, the means for introducing air comprises an annular space formed between the gas supply pipe and the end of the stack pipe, through the use of different diameter pipes.

5 [0016] The introduced air and the gas mix in the mixing zone. The ignitable gas and air mixture is then ignited. The means for igniting the gas and air mixture may comprise any means known to the art for igniting combustible gases, including, but not limited to, pilot burners, spark generators and the like. The means for igniting may be located at any position in the apparatus of the present invention where sufficient mixing of the gas and air mixture has occurred to produce an ignitable mixture. Preferably, the means for igniting is located at a position where the flame, or other igniting means, penetrates the recirculation zone created by the means for stabilizing the ignited gas and air mixture.

10 [0017] In the apparatus and method of the present invention, the ignited gas and air mixture is stabilized to promote substantially complete burning of the combustible components of the gas stream. The means for stabilizing the ignited gas and air mixture comprise means for creating a recirculation zone wherein the ignited gas and air mixture recirculates. As described below in the more detailed description of the invention, the means for stabilizing may comprise a step between a first stack pipe that communicates with the gas supply pipe and a second stack pipe that emits the burned gas and air mixture into the atmosphere. The means for stabilizing may alternatively comprise an object, preferably a cone or hemisphere, located in the interior of the stack pipe that creates recirculation.

15 [0018] After combustion of the combustible components of the gas stream has been achieved, the resultant gaseous products are emitted from the stack pipe into the atmosphere. The emitting end of the stack pipe includes downwash inhibiting means to ensure that the gaseous products resulting from combustion of the gas and air mixture are emitted upwardly into the atmosphere.

[0019] The method and apparatus of the present invention advantageously burns the combustible components of a gas stream to minimize the emission of pollutants and smoke into the atmosphere.

20 [0020] Further details and advantages of the apparatus and method of the present invention are set forth in the following more detailed description of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS:

[0021]

30 Figure 1 depicts an embodiment of the apparatus of the present invention.
Figure 2 depicts an alternate embodiment of the apparatus of the present invention.

DETAILED DESCRIPTION OF THE INVENTION:

35 [0022] The apparatus of the present invention is particularly advantageous for use on the end of smoke stacks emitting combustible gases from industrial processes.

[0023] An embodiment of the apparatus of the present invention is depicted in Figure 1. As will be readily understood by those of ordinary skill in the art, the apparatus shown in Figure 1 is designed to be constructed over the end of a smoke stack emitting combustible gases.

40 [0024] With reference to Figure 1, the apparatus of the present invention, 1, includes a stack pipe, 4, in communication with a gas supply pipe, 2. The inner diameter of the gas supply pipe, 2, is shown as D1 and the inner diameter of the stack pipe, 4, is shown as D2. The arrangement of supply pipe, 2 and stack pipe, 4 should be such that the possibility of gas escaping into the atmosphere is minimized. It is preferred that the pipes overlap as shown in Figure 1. In Figure 1, D1 is smaller than D2, and gas supply pipe 2, extends into stack pipe 4, thereby creating means, 5, for introducing air into the stack pipe, 4. The distance that the pipes overlap is shown as H1.

45 [0025] In the embodiment of the apparatus of the present invention shown in Figure 1, the means for introducing air into the stack pipe, 5, comprises the annular space between the gas supply pipe, 2 and the stack pipe, 4. Air is drawn through the annular space into the stack pipe 4. As set forth above, the amount of air drawn into stack pipe, 4 should be sufficient to produce an ignitable gas and air mixture. Such determination is within the skill of those of ordinary skill in the art. As also set forth above, the means for introducing air into stack pipe, 4, may alternately comprise other means known in the art such as an air supply pipe in communication with stack pipe, 4.

50 [0026] The air mixes with the gases emitted from gas supply pipe, 2, in mixing zone, 6, to form an air and gas mixture. The length of the mixing zone should be sufficient to allow sufficient mixing time for the introduced air and gas to produce an ignitable air gas mixture. In Figure 1, the length of the mixing zone is shown as H2.

55 [0027] Stack pipe, 4, containing mixing zone, 6, communicates with one end of stack pipe, 10, having inner diameter, D3, and containing means, 14 for igniting the air and gas mixture. Means 14, may comprise any means known to the art for igniting combustible gases, including, but not limited to: pilot burners, spark generators and the like.

5 [0028] The means for igniting, 14 may be located at any position in the apparatus of the present invention where sufficient mixing of the gas and air mixture has occurred to produce an ignitable mixture. Preferably, the means for igniting is located at a position wherein the flame, or other igniting means, penetrates the recirculation zone created by the means for stabilizing the ignited gas and air mixture. In the embodiment depicted in Figure 1, the means for igniting, 14, are located a distance P from the end of stack pipe, 4, containing mixing zone, 6. The apparatus of the present invention includes at least one means for igniting, and preferably includes more than one means for igniting spaced around the periphery of stack pipe, 10.

10 [0029] Once the gas and air mixture has been ignited, the mixture will generally remain burning. Thus, once ignition occurs, the means for igniting may be turned off. Preferably, however, the means for igniting is not turned off to ensure a constant burning of the air and gas mixture.

[0030] In the embodiment of the present invention depicted in Figure 1, D3 is greater than D2, thereby creating step, 8, having a cross sectional width of W2. The width, W2 should be sufficient to create a stabilization zone for the ignited air and gas mixture. Stabilization is achieved by recirculation of the ignited air and gas mixture.

15 [0031] The length of stack pipe, 10, is shown as H3. Preferably, the length H3 should be sufficient to permit substantially complete combustion of the combustible components of the ignited air and gas mixture.

20 [0032] The other end of stack pipe, 10, communicates with the atmosphere and includes means for inhibiting downwash, 12, to ensure that the gaseous products resulting from combustion of the gas and air mixture are emitted upwardly into the atmosphere. As shown in Figure 1, the means for inhibiting downwash, 12, may comprise a frustoconically flared portion of stack pipe, 10, which increases the diameter of stack pipe, 10, to diameter D4. The length and width of the flared portion of stack pipe, 10, which comprises the downwash inhibiting means, are shown as H4 and W3 respectively.

[0033] The apparatus of the present invention may be constructed from materials known to those of ordinary skill in the art. Suitable materials include, but are not limited to: stainless steel, refractory materials and the like.

25 [0034] With reference to Figure 1, in the method of the present invention, gas emitted from gas supply pipe, 2 mixes with air in mixing zone, 6. The resulting air and gas mixture travels into stack pipe, 10 where the mixture is ignited by ignition means, 14. The resulting ignited mixture is stabilized as a result of step, 8. The combustible components of the air and gas mixture continue to burn in stack pipe, 10 and are discharged into the atmosphere. Downwash inhibiting means, 12, helps to ensure that the combustion products from the ignited gas and air mixture are emitted upwardly into the atmosphere.

30 [0035] Figure 2 depicts an alternate embodiment of the apparatus of the present invention. In the apparatus depicted in Figure 2, internal flame stabilization means, 20, is provided in stack pipe, 10. The internal flame stabilization means, 20, comprise any object that creates recirculation, preferably a cone or hemisphere and is suspended in the stream flowing through stack pipe 10. The remainder of the apparatus shown in Figure 2 is similar to the apparatus shown in Figure 1 except that in the Figure 2 apparatus, the step, 8, between stack pipes, 4 and 10, has been omitted. The dimensions, including length and internal diameter, of the stack pipes, downwash inhibiting means, and other parts of the apparatus depicted in Figure 2 may, or may not, be the same as those described with reference to Figure 1.

35 [0036] The apparatus can be constructed with both the internal flame stabilization means, 20, and external flame stabilization means in the form of the step, 8, between stack pipes 4 and 10.

40 [0037] With reference to Figure 2, in the method of the present invention, gas emitted from gas supply pipe, 2 mixes with air in mixing zone, 6. The resulting air and gas mixture travels into stack pipe, 10 where the mixture is ignited by ignition means, 14. The resulting ignited mixture by stabilizing means 20. The combustible components of the air and gas mixture continue to burn in stack pipe, 10 and are discharged into the atmosphere. Downwash inhibiting means, 12, helps to ensure that the combustion products from the ignited gas and air mixture are emitted upwardly into the atmosphere.

45 [0038] Further details of the apparatus and method of the present invention, and their advantages, will become apparent from the following Example.

50 [0039] A vacuum generator Prima 600 process industrial mass spectrometer, manufactured by VG Gas Analysis System, Ltd. of the United Kingdom was utilized to determine the composition of the gas streams referred to in the following Example. Instructions for utilizing the spectrometer accompany the machine. The gas streams were dried to approximately 2% water, by weight, prior to analysis using Perma Pure dryers, manufactured by Perma Pure Products, Incorporated, of Toms River, New Jersey.

EXAMPLE:

55 [0040] This example illustrates the effectiveness of the method and apparatus of the present invention.

[0041] An apparatus of the present invention, as depicted in Figure 1, was placed in communication with the combustion gas stream emitted from a carbon black furnace reactor during a carbon black production run. The apparatus of the present invention was constructed from stainless steel and utilized a propane burner to ignite the air and gas

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mixture. The geometry, and operating conditions, utilized are set forth in Table 1.

Table 1

Apparatus Geometry		
D-1		76.2 mm (3.00 in)
D-2		109.5 mm (4.31 in)
D-3		190.5 mm (7.50 in)
D-4		314.5 mm (12.38 in)
H-1		76.2 mm (3.00 in)
H-2		266.7 mm (10.50 in)
H-3		190.5 mm (7.50 in)
H-4		62.0 mm (2.44 in)
W-1		16.8 mm (0.66 in)
W-2		40.4 mm (1.59 in)
W-3		62 mm (2.44 in)
P (in.)		38.1 mm (1.50 in)
Propane Flow to Ignitor		0.076 m ³ /hr (2.67 scfh)
Ignitor Nozzle Size		12.7 mm (0.50 in)
Feed gas Rate		265 m ³ /hr (9.35 kscfh)
Feed gas Moisture (vol. %)		35.3
Feed gas Heat Value		2.46 MJ/m ³ (66 BTU/SCF)
Temperature in Supply Pipe, 2		123°C (254°F)
Stream Velocity in Supply Pipe, 2		0.6 m/s (73 ft/s)

in. = inch(es); scfh=standard cubic feet per hour; kscfh = thousand standard cubic feet per hour vol; % = volume percentage; BTU = British thermal unit; °F = degrees Fahrenheit; ft./s = feet per second

[0042] The compositions of the gas streams entering and leaving the apparatus of the present invention were determined, after drying, according to the procedures described herein. The results are set forth in Table 2 below:

Table 2 -

Dried Gas Stream Composition		
Compound	Entering Stream	Exiting Stream
N ₂ (vol.%)	62.50	84.18
O ₂ (vol. %)	3.56	0.00
CO ₂ (vol. %)	2.44	13.61
Ar (vol. %)	0.67	0.99
C ₂ H ₂ (vol. %)	0.223	<0.003
H ₂ (vol. %)	14.99	0.18
CO (vol. %)	14.55	0.82
CH ₄ (vol. %)	0.772	<0.003
H ₂ S (ppmv)	626	<31
SO ₂ (ppmv)	631	2249
CS ₂ (ppmv)	959	<15
COS (ppmv)	233	< 15

vol. % = volume percentage; ppmv = volume parts per million.

The results provided in Table 2 indicate that the method and apparatus of the present invention reduce the emission levels of all of the combustible components, including CS₂, COS, and H₂S in the gas stream. These results also make it apparent that the combustion efficiency of the apparatus of the present invention is high.

[0043] These results indicate that the method and apparatus of the present invention are advantageous for use in burning the combustible components of gases.

Claims

1. An apparatus for burning the combustible components of a gas stream comprising;

5 a stack pipe comprising a first end and a second end, said first end being in communication with a gas supply pipe (2) for receiving a gas stream;
 means (5) for introducing air into the stack pipe to produce an air and gas mixture in a mixing zone (6);
 means (14) for igniting the air and gas mixture;
 10 means (12) being provided at the second end of the stack pipe for inhibiting downwash of the gaseous products resulting from combustion of the gas and air mixture

characterised in that:

15 means are provided for recirculating the ignited air and gas mixture to provide contact between the ignited air and gas mixture and the unignited air and gas mixture; the means for recirculating the ignited air and gas mixture comprising a step (8) in the stack pipe or internal recirculation means (20) suspended in the interior region of the stack pipe.

20 2. The apparatus of Claim 1 further comprising a first and a second stack pipes (4, 10) wherein the first stack pipe (4) contains the mixing zone (6), the means (14) for igniting the air and gas mixture are located in the second stack pipe (10) in communication with the first stack pipe and having a diameter (D3) larger than the first stack pipe (D2), and wherein the means for recirculating the ignited air and gas mixture comprises the step (8) between the first (4) and the second (10) stack pipes.

25 3. A method for burning the combustible components of a gas stream comprising:

introducing a gas stream (22) containing combustible components into one end of a stack pipe;
 introducing air into the stack pipe to produce an air and gas mixture;
 mixing the air and gas mixture in a mixing zone;
 30 igniting the air and gas mixture;
 allowing the gaseous products resulting from combustion of the gas and air mixture to exit the stack pipe; downwash of the gaseous products being inhibited; and **characterized in that** the ignited air and gas mixture produced by igniting the air and gas mixture is recirculated such that a portion of the ignited gas and air mixture contacts a portion of the air and gas mixture prior to igniting, wherein the method for recirculating the portion
 35 of the ignited gas and air mixture comprises forming a step in the stack pipe, or suspending internal recirculation means in the interior of the stack pipe.

40 4. The method of Claim 3 wherein recirculation occurs through the use of a first and a second stack pipes in which the first stack pipe has a diameter smaller than the second stack pipe and the method comprises mixing the air and gas mixture in a mixing zone located in the first stack pipe and recirculating the portion of the ignited air gas mixture through the use of the step between the first and second stack pipes.

45 5. The method of Claim 4 further comprising suspending internal flame recirculation means in the interior region of the stack pipe to provide recirculation.

Patentansprüche

1. Vorrichtung zur Verbrennung der brennbaren Komponenten eines Gasstroms;

50 mit einem Kaminrohr mit einem ersten und einem zweiten Ende, wobei das erste Ende mit einem Gaszuführrohr (2) zur Aufnahme eines Gasstroms in Verbindung steht;
 mit Mitteln (5) zur Einführung von Luft in das Kaminrohr und zur Schaffung eines Luft/Gas-Gemischs in einer Mischzone (6);
 mit Mitteln (14) zur Zündung des Luft/Gas-Gemischs;
 55 und mit Mitteln an dem zweiten Ende des Kaminrohrs zur Verhinderung des Rückschlagens der aus der Verbrennung des Gas/Luft-Gemischs herrührenden gasförmigen Produkte,
dadurch gekennzeichnet,
daß Mittel zur Rezikulierung des gezündeten Luft/Gasgemischs vorgesehen sind, um einen Kontakt zwi-

schen dem gezündeten Luft/Gas-Gemisch und dem ungezündeten Luft/Gas-Gemisch herzustellen, wobei die Mittel zur Rezirkulierung des gezündeten Luft/Gas-Gemischs eine Stufe (8) in dem Kaminrohr oder innere Rezirkulationsmittel (20) umfassen, die im Innenbereich des Kaminrohrs aufgehängt sind.

- 5 2. Vorrichtung nach Anspruch 1 mit ersten und zweiten Kaminrohren (4, 10), wobei das erste Kaminrohr (4) die Mischzone (6) enthält und wobei die Mittel (14) zur Zündung des Luft/Gas-Gemischs in dem zweiten Kaminrohr (10) vorgesehen sind, welches mit dem ersten Kaminrohr in Verbindung steht und einen größeren Durchmesser (D 3) als das erste Kaminrohr (D 2) aufweist und wobei die Mittel zur Rezirkulierung des gezündeten Luft/Gas-Gemischs die Stufe (8) zwischen dem ersten Kaminrohr (4) und dem zweiten Kaminrohr (10) umfassen.
- 10 3. Verfahren zur Verbrennung der brennbaren Komponenten eines Gasstroms,
bei welchem ein Gasstrom (22) mit brennbaren Komponenten in ein Ende eines Kaminrohrs eingeführt wird;
bei welchem zur Schaffung eines Luft/Gas-Gemischs Luft in das Kaminrohr eingeführt wird;
15 bei welchem das Luft/Gas-Gemisch in einer Mischzone vermischt wird;
bei welchem das Luft/Gas-Gemisch gezündet wird;
bei welchem die aus der Verbrennung des Luft/Gas-Gemischs resultierenden gasförmigen Produkte aus dem Kaminrohr austreten gelassen werden;
und bei welchem ein Zurückschlagen der gasförmigen Produkte verhindert wird,
20 **dadurch gekennzeichnet, daß** das durch die Zündung des Luft/Gas-Gemischs erzeugte gezündete Luft/Gas-Gemisch derart rezirkuliert wird, daß ein Teil des gezündeten Luft/Gas-Gemischs einen Teil des Luft/Gas-Gemischs vor dessen Zündung kontaktiert, wobei das Verfahren zur Rezirkulierung des Teils des gezündeten Luft/Gas-Gemischs die Ausbildung einer Stufe in dem Kaminrohr oder die Aufhängung eines Rezirkulationsmittel im Innern des Kaminrohrs umfaßt.
- 25 4. Verfahren nach Anspruch 3, wobei die Rezirkulation durch die Verwendung eines ersten und eines zweiten Kaminrohrs geschieht, wobei das erste Kaminrohr einen kleineren Durchmesser als das zweite Kaminrohr aufweist und das Verfahren die Durchmischung des Luft/Gas-Gemischs in einer Mischzone umfaßt, die in dem ersten Kaminrohr gelegen ist und die Rezirkulierung des Teils des gezündeten Luft/Gas-Gemischs mit Hilfe einer Stufe zwischen dem ersten Kaminrohr und dem zweiten Kaminrohr umfaßt.
- 30 5. Verfahren nach Anspruch 4, wobei zur Herbeiführung der Rezirkulation in dem inneren Bereich des Kaminrohrs innere Flammenrezirkulationsmittel aufgehängt werden.

35 **Revendications**

1. Dispositif pour brûler les composants combustibles d'un courant gazeux comprenant :

40 un tuyau faisceau comprenant une première extrémité et une deuxième extrémité, ladite première extrémité étant en communication avec un tuyau d'alimentation de gaz (2) pour recevoir un courant gazeux ;
des moyens (5) pour introduire de l'air dans le tuyau faisceau pour produire un mélange d'air et de gaz dans une zone de mélange (6) ;
des moyens (14) pour enflammer le mélange d'air et de gaz ;
des moyens (12) disposés à la deuxième extrémité du tuyau faisceau pour inhiber le rabattement des produits gazeux résultant de la combustion du mélange d'air et de gaz ;

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caractérisé en ce que :

50 des moyens sont fournis pour provoquer une recirculation du mélange d'air et de gaz enflammé afin de mettre en contact le mélange d'air et de gaz enflammé et le mélange d'air et de gaz non enflammé, comprenant une marche (8) dans le tuyau faisceau ou des moyens de recirculation internes (20) suspendus dans la région intérieure du tuyau faisceau.

- 55 2. Dispositif selon la revendication 1 comprenant en outre un premier et un second tuyau faisceau (4, 10) dans lequel le premier tuyau faisceau (4) contient la zone de mélange (6), les moyens (14) pour enflammer le mélange d'air et de gaz sont situés dans le deuxième tuyau faisceau (10) en communication avec le premier tuyau faisceau et ayant un diamètre (D3) plus grand que le premier tuyau faisceau (D2) et dans lequel les moyens de provoquer la recirculation du mélange d'air et de gaz enflammé comprennent la marche (8) entre le premier (4) et le second

(10) tuyau faisceau.

3. Procédé pour brûler les composants combustibles d'un courant gazeux comprenant :

- 5 on introduit un courant gazeux (22) contenant les composants combustibles à une extrémité d'un tube faisceau ;
on introduit de l'air dans le tube faisceau pour produire un mélange d'air et de gaz ;
on mélange le mélange d'air et de gaz dans une zone de mélange ;
on enflamme le mélange d'air et de gaz ;
10 on laisse les produits gazeux résultant de la combustion du mélange de gaz et d'air sortir du tube faisceau ;
on inhibe le rabattement des produits gazeux ;

et caractérisé en ce que :

- 15 le mélange d'air et de gaz enflammé produit par l'inflammation du mélange d'air et de gaz est mis en recirculation de sorte qu'une portion du mélange d'air et de gaz enflammé est mise en contact avec une portion du mélange d'air et de gaz avant inflammation, dans lequel le procédé pour provoquer la recirculation de la portion du mélange d'air et de gaz enflammé comprend la formation d'une marche dans le tube faisceau ou la suspension de moyens de recirculation interne à l'intérieur du tube faisceau.

- 20 4. Procédé selon la revendication 3, dans lequel la recirculation est produite grâce à l'utilisation d'un premier et d'un second tubes faisceau dans lequel le premier tube faisceau a un diamètre plus petit que le second tube faisceau et le procédé comprend le mélange du mélange d'air et de gaz dans une zone de mélange située dans le premier tube faisceau et la recirculation de la portion du mélange d'air et de gaz enflammé par l'utilisation de la marche entre le premier et le deuxième tube faisceau.

- 25 5. Procédé selon la revendication 4, comprenant en outre la suspension de moyens de recirculation de flamme internes dans la région intérieure du tube faisceau pour provoquer une recirculation.

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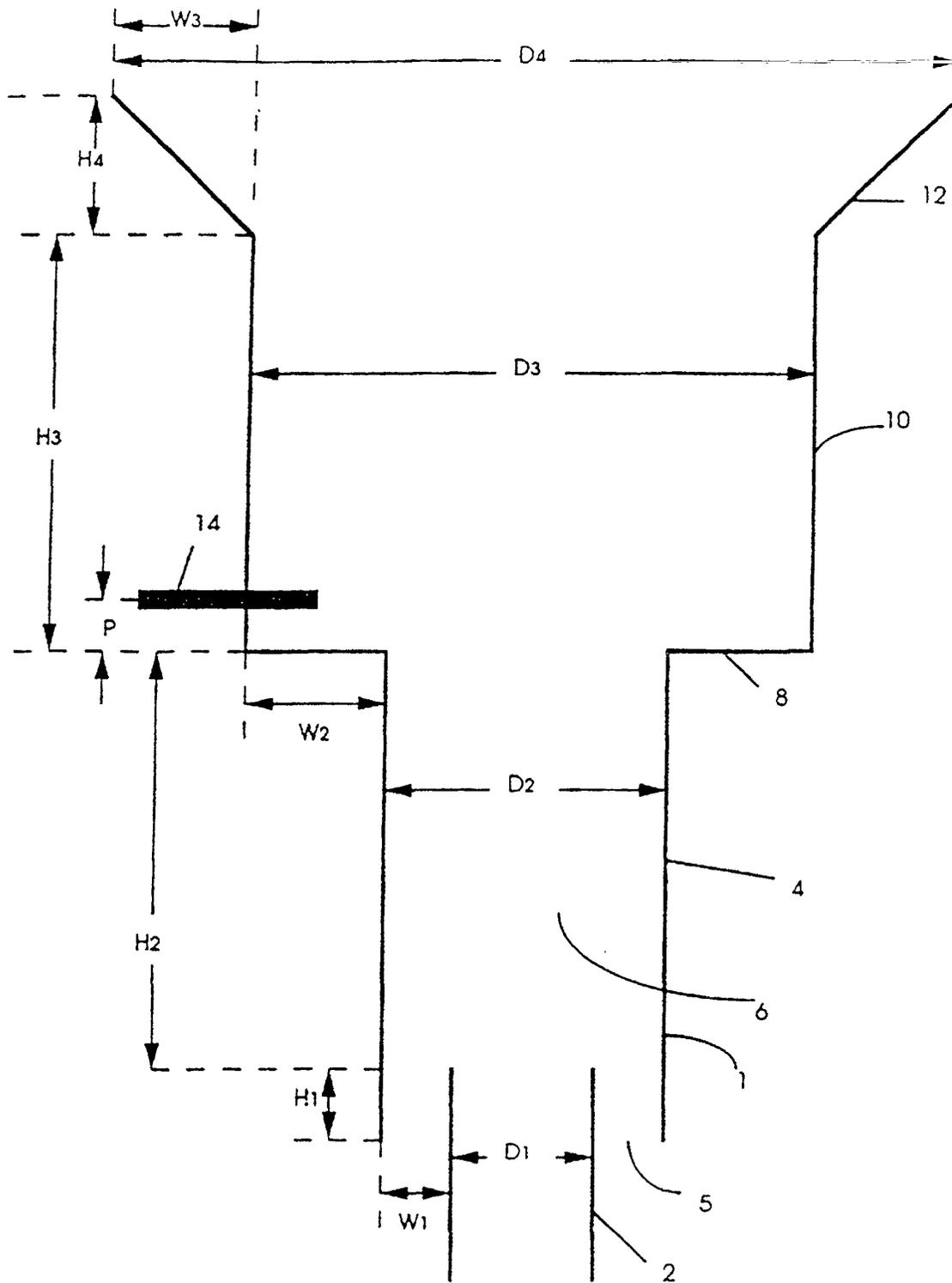


FIGURE 1

