United States Patent [19]

Smith et al.

[11] **3,904,351**

[45] **Sept. 9, 1975**

[54] **COMBUSTOR AND METHOD OF ELIMINATING ODORS USING THE SAME**

[75] Inventors: **James Robert Smith**, Plattsmouth; **John Pierce Kendall**, Omaha, both of Nebr.

[73] Assignee: **Northern Natural Gas Company**, Omaha, Nebr.

[22] Filed: **Sept. 13, 1974**

[21] Appl. No.: **505,727**

Related U.S. Application Data

[63] Continuation of Ser. No. 406,586, Oct. 15, 1973, abandoned.

[52] **U.S. Cl.** ..... **431/284**; 431/285; 431/202; 23/277 C

[51] **Int. Cl.**[2] **F23Q 9/00**

[58] **Field of Search** ..... 431/284, 285, 202; 23/277 C; 110/8 A

[56] **References Cited**

UNITED STATES PATENTS

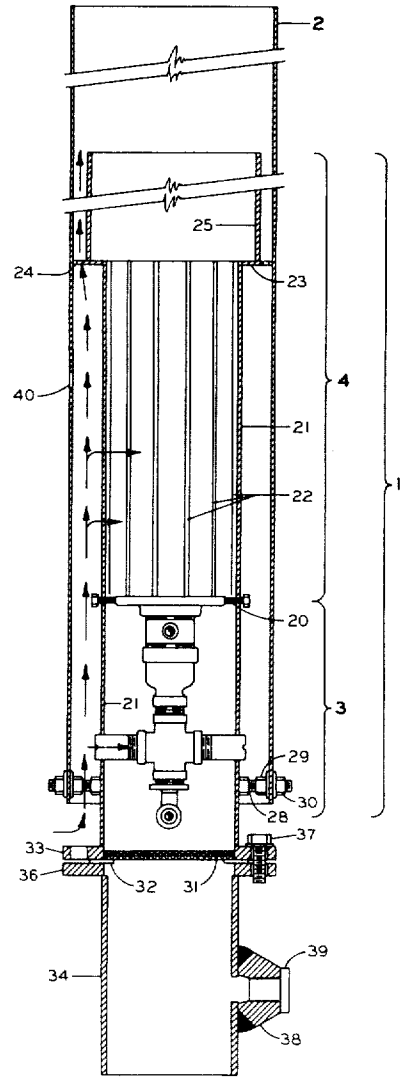
2,879,862	3/1959	Burden	110/72
2,996,143	8/1961	Beasley	431/202
3,244,220	4/1966	Kloecker	431/5
3,248,178	4/1966	Hoskinson	23/277
3,256,924	6/1966	Campbell et al.	431/9
3,864,072	2/1975	Abernathy et al.	23/277 C

Primary Examiner—Carroll B. Dority, Jr.
Attorney, Agent, or Firm—Donald F. Haas

[57] **ABSTRACT**

A lightweight, relatively inexpensive, combustor to treat oxidizable effluents containing noxious odorous contaminants which includes a burner zone which produces a flame to preheat and ignite a mixture of air and the contaminated effluent in a secondary combustion zone thereby decomposing the contaminants.

6 Claims, 2 Drawing Figures



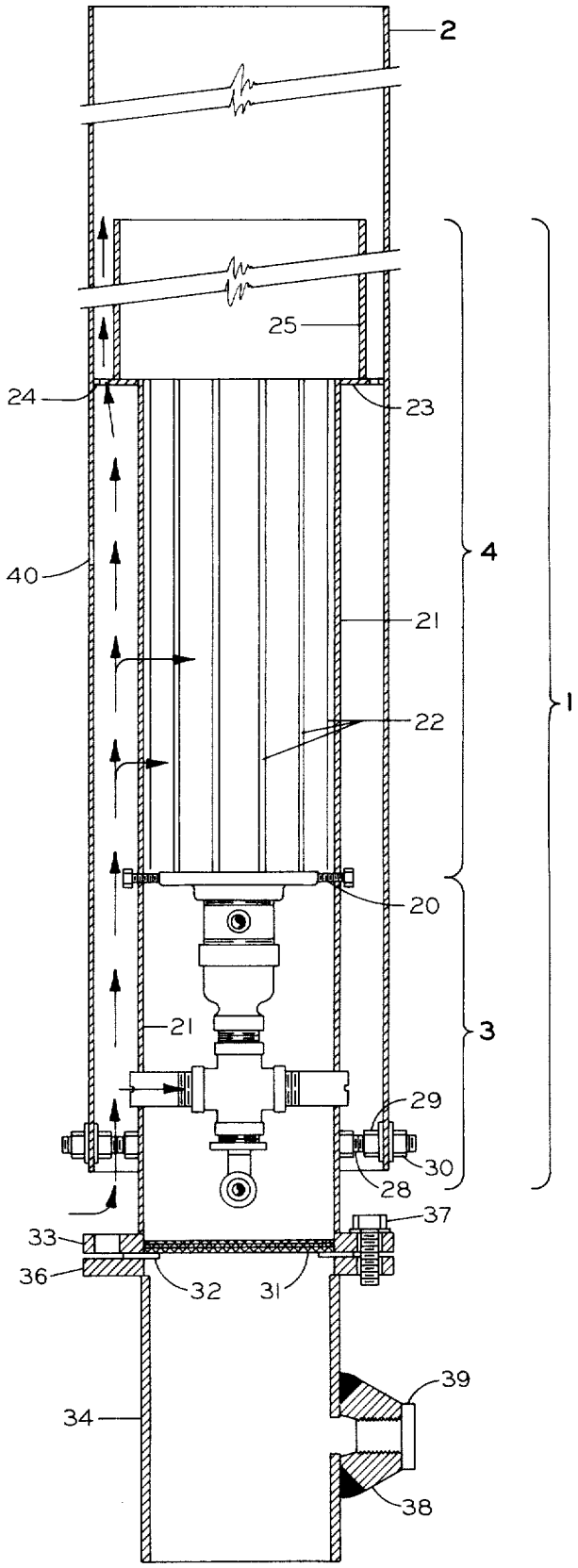


FIG. 1

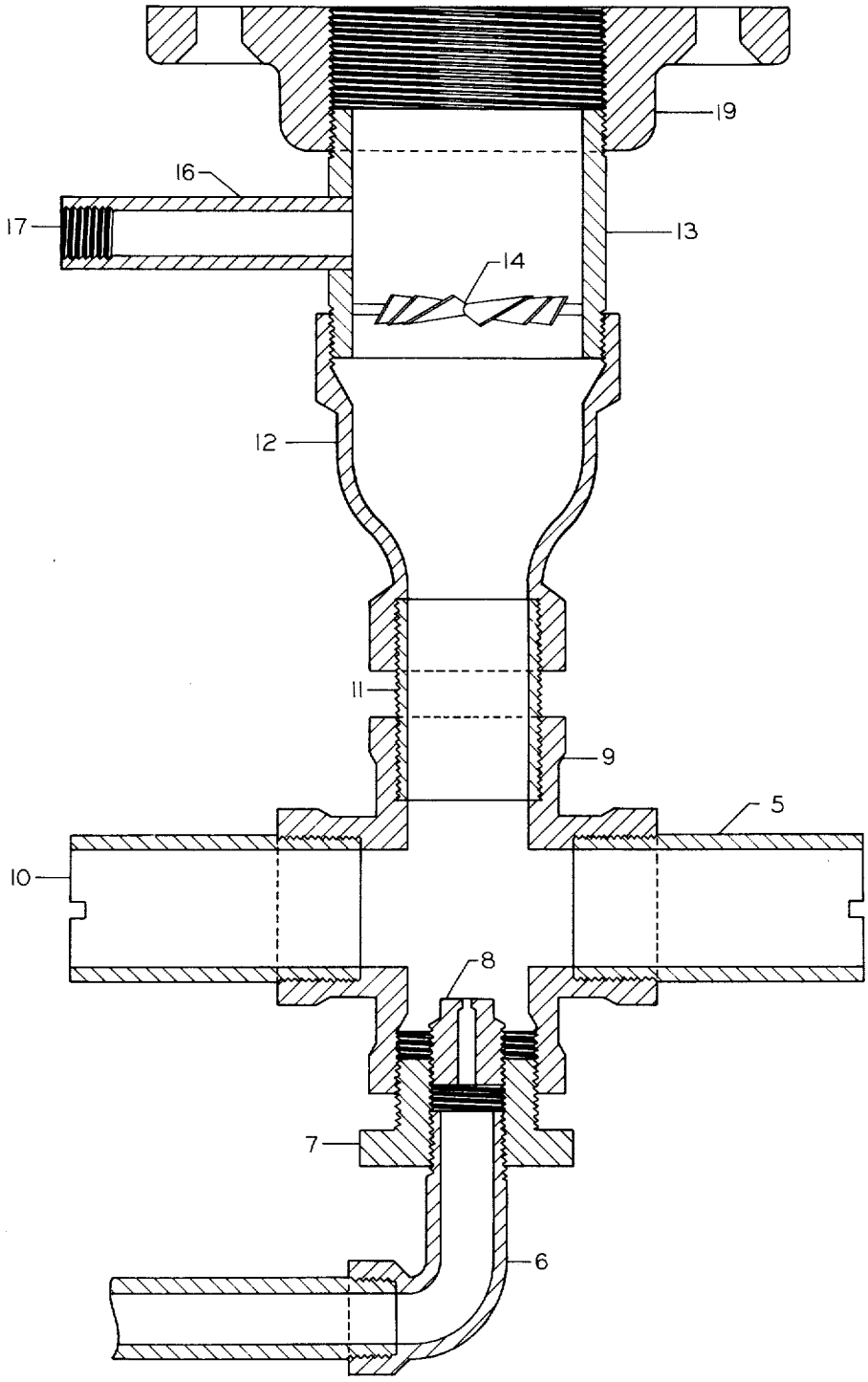


FIG. 2

COMBUSTOR AND METHOD OF ELIMINATING ODORS USING THE SAME

CROSS REFERENCE TO RELATED APPLICATION

This application is a continuing application of our earlier application of the same title, Ser. No. 406,586, filed Oct. 15, 1973 and now abandoned.

FIELD OF THE INVENTION

This invention relates to combustors or burners. In a further aspect, this invention relates to an apparatus of decomposing gases containing noxious odorous contaminants to eliminate such odors. In a still further aspect, the invention relates to a method of decomposing odorous contaminants contained in a combustible effluent from various chemical processes.

BACKGROUND OF THE INVENTION

The elimination of odorous materials from discharge effluents of numerous chemical processes is a continuing problem. In many situations, contaminant levels of such effluents are relatively low, but the odorous nature of the contaminant is such to offend nearby citizens. Heretofore, flaring of these effluents has been a common practice, particularly in remote, lightly populated areas. However, flaring has been found to be inadequate due to incomplete combustion of the effluent. Usually, incomplete combustion is the result of inadequate air-effluent mixing prior to ignition or the presence of constituents in the effluent which generally lower the flammability of the effluent. It is the latter problem that is particularly difficult to eliminate because the art has failed to provide an inexpensive method and apparatus which can operate over a wide range of flammability limits.

The prior art is replete with examples of secondary combustion devices and afterburners, such as those described in U.S. Pats. Nos. 2,879,862 by Burden, 3,244,220 by Kloecker, 3,256,924 by Campbell, et al., and 3,567,399 by Atmann, et. al. However, all of these devices require a refractory material or other insulation in their construction and, thus, are too heavy for many uses and are relatively expensive. U.S. Pat. No. 2,966,143 by Beasley discloses a device which does not require a refractory material in its construction, but is primarily a smoke eliminator and does not incorporate or suggest the optimum air mixing utilized in the device of the present invention at the secondary combustion zone.

SUMMARY OF THE INVENTION

Briefly described, the combustor of the present invention comprises an elongated cylindrical stack open at the upstream end to allow entry of the noxious odorous materials to be burned and at the downstream end to allow the burned gases to exit an effluent combustion tube housed within the stack which defines a burner zone and a secondary combustion zone, and means within the stack for injecting a combustible fuel and air into the burner zone to form a fuel-air mixture and for injecting air into the space between the stack and the tube. The effluent combustion tube has openings formed in it at the secondary combustion zone for allowing the passage of air through the tube into the secondary combustion zone at an angle of approximately 90° to the flow of gases within the secondary combustion zone.

The burner zone includes an expansion zone where the fuel-air mixture is formed, a plurality of radially extending inclined swirl blades located downstream of the expansion zone which impart swirling motion to the mixture as it flows through the openings formed between the blades, and a primary combustion chamber in which the mixture is ignited and from which it moves into the secondary combustion zone and then out the downstream end of the stack following complete combustion thereof. The primary combustion zone is located immediately downstream from the swirl blades and immediately upstream from the secondary combustion zone.

The combustor further comprises means for allowing the noxious odorous materials entering the upstream end of the stack to pass through the effluent combustion tube. In doing so, they pass around the burner zone and into the secondary combustion zone. There they ignite upon coming into contact with the ignited fuel-air mixture and are completely burned before they exit out the downstream end of the stack.

In a preferred embodiment, the openings in the effluent combustion tube are in the form of longitudinal slots extending from the end of the tube adjacent the burner zone to its opposite end. In another preferred embodiment, the swirl blades are inclined 30° to 40° from the cross-sectional axis of the combustor and the openings between the blades extend across two-thirds to three-fourths of the radius of the primary combustion chamber.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 of the drawing is a cross-sectional view of the preferred embodiment of the combustor of this invention.

FIG. 2 of the drawing is an enlarged cross-sectional view of the primary burner zone of the combustor depicted in FIG. 1.

DETAILED DESCRIPTION OF THE INVENTION

With reference to FIG. 1 of the drawing, the combustor 1 of the present invention is housed in an elongated cylindrical stack 2 and comprises a burner zone 3 and a secondary combustion zone 4. The burner zone 3 is shown in an enlarged view in FIG. 2.

The burner zone 3 includes a primary fuel inlet 6, an injection nozzle 8, an expansion and mixing zone 12, swirl blades 14 and a primary combustion chamber 13. Readily combustible gaseous fuel flows into fuel inlet 6 and is then passed through the restricted orifice of nozzle 8 which is held in place by threaded bushing 7, and passed upward into the expansion zone 12. The nozzle imparts a high velocity to the fuel to promote good mixing of the fuel and air. Air inlet ports 10 are provided by threaded cross 9 which received air inlet pipes 5. The cross 9 is also threaded to mate with bushing 7, and a threaded nipple 11. The air and fuel mixture is passed through nipple 11 into the expansion zone 12. The expanded fuel and air mixture is then passed through stationary swirl blades 14 which impart a rotational motion to the fuel-air mixture. The swirled fuel-air mixture then passes into primary combustion chamber 13.

Within primary combustion chamber 13 an igniter tube 16 is positioned immediately above the swirl blades 14, and an ignition source, such as a spark plug, is suitably mounted into the outer end of tube 16, for

example, by way of threads **17.** Activation of the ignition source results in combustion of the fuel-air mixture immediately above the swirl blades **14** and the resulting flame passes through the primary combustion chamber **13** and into the lower portion of the secondary combustion zone **4.**

The stationary swirl blades **14** also cause the combustion products produced in chamber **13** to circulate both rotationally and downwardly in a vortex motion to insure a constant ignition source for the primary fuel-air mixture. To insure that the flame remains burning without constant use of the ignition source within the igniter tube **16,** the swirl blades **14** should be inclined 30° to 40° from the cross-sectional axis of the combustor **1** and the openings between the blades **14** should extend across two-thirds to three-fourths of the radius of the primary combustion chamber **13.** The swirl blades **14** give the following advantages over the other ways to keep a constant flame: (1) no need for a flame-holder which could wear out, (2) simpler in construction, (3) takes up less space, (4) lighter weight, (51) less expensive, and (6) creates less of a pressure drop which might prevent the aspiration of air into the burner zone **3.**

As shown in FIG. **1,** both the burner zone **3** and the secondary combustion zone **4** are housed within an effluent combustion tube **21.** The burner zone **3** is maintained in alignment within the effluent combustion tube **21** by means of alignment bolts **20** which are threaded through effluent combustion tube **21** and rest upon the outer surface of the flow diverter **19.** In the upper portion of effluent combustion tube **21** are provided longitudinal air slots **22** which allow the entry of air into the secondary combustion zone **4.** This promotes mixing of effluent and air, and also cools the effluent combustion tube **21,** obviating the need for refractory insulation. Upstream from the terminus of the air slots, there is provided a flange **23** having therein a plurality of air ports **24.** Attached to the outer portion of flange **23** is a stack heat shield **25** which extends downstream from the effluent combustion tube **21.**

In operation, a contaminated gaseous effluent containing noxious odorous materials is passed through flame arrestor **31** into the effluent combustion tube **21** in the region below the position of the primary burner zone **3.** Simultaneously therewith, air is introduced into the combustor in the annular space between burner stack **2** and the effluent combustion tube **21** in the region of the stack mounting bolts **28.** The air flow is depicted by arrows in FIG. **1.** Air moves upwardly in the annular space and enters air inlet ports **10,** air slots **22** and air ports **24.** The contaminated gaseous effluent passes around the primary burner zone **3** and traverses the annular space between the flow diverter **19** and the effluent combustion tube **21,** thus increasing the velocity thereof. As the effluent passes the upper portion of the primary burner zone **3,** the burner flame increases the temperature thereof and draws air through slots **22** into the effluent combustion tube **21.** This causes the effluent to undergo a rapid increase in temperature and a region within the effluent combustion tube **21** immediately above the primary burner flame becomes a preheat zone wherein the combustion effluent and air mixture is raised to ignition temperature. Ignition of the effluent occurs within the effluent combustion tube and the flame produced thereby exits the tube in the region of flange **23.**

Air flows toward the axis of the secondary combustion zone **4** from each of the longitudinal slots, dividing the effluent into narrower streams. Depending on the composition temperature and flow rate of the effluent for a given size device, combustion can begin anywhere from the center of the zone to the air inlets, exhausting the local supply of air until fresh air comes in downstream. In either case, the effluent stream gets mixed gradually over a long path so that regardless of the overall ratio of air to combustibles there is always a place within the zone **4** where the ratio is proper to support ignition. It is important that the air enter the secondary combustion zone **4** at an angle of approximately 90° to the flow of gases therein. It has been discovered in accordance with the present invention that a 90° angle of entry effects the best possible mixing of the combustion effluent and air to insure that there is always a place where the overall ratio is sufficient to support ignition.

The purpose of the heat shield **25** is to protect the stack **2** without the necessity of using refractory insulation. Air which enters by way of heat shield air ports **24** is convected upwardly along the outer surface of heat shield **25,** thus cooling it and preventing burnout from the secondary combustion effluent. This same air prevents direct impingement of secondary combustion effluents on the stack **2** downstream of the heat shield **25,** thereby protecting the stack **2** from burnout.

Located immediately below the primary combustion zone **3,** flame arrestor **31** is suitably mounted to prevent the encroachment of any flame into the lower region of the stack **2** on which the combustor **1** is mounted. Preferably, the flame arrestor **31** is positioned as depicted in FIG. **1.** The flame arrestor **31** is provided with a flame arrestor flange **32** on the outer circumference thereof. Effluent combustion tube **21** is provided with a flange **33** on the outer surface thereof. A cooperative arrangement is provided on inlet means **34** in the form of flange **36.** The flame arrestor flange **32** is positioned between flanges **33** and **36** and secured by means of bolts **37.** This arrangement allows for easy access and removal of the flame arrestor **31** in the event that the same should become clogged with materials which are entering the combustor **1.**

The combustor **1** may be mounted on any effluent discharge device such as a flare stack. The inlet means **34** is merely welded to the top of such device. It is also desirable to provide an auxiliary inlet **38** within inlet means **34** to provide for the entry of additional combustible materials into admixture with the contaminated effluent. When not in use, the auxiliary inlet **38** can be suitably plugged by way of a threaded plug such as that shown by reference numeral **39.**

The stack **2** can be mounted in any manner which is sufficient to allow the entry of air into the burner zone **3** and the secondary combustion zone **4.** As shown in FIG. **1,** stack mounting bolts **28** are affixed to effluent combustion tube **21** and lock nut **29** and retaining nut **30** position the stack **2** about the circumference of the effluent combustion tube **21** and the stack heat shield **25.** The stack **1** has a hole **40** formed therein near the downstream end of the secondary combustion zone **4.** The purpose of this hole **40** is to relieve the pressure build-up at the place of the most intense combustion and thereby prevent oscillatory combustion which is extremely noisy and which could damage the combustor **1.**

The hydrocarbon fuel employed in the burner zone 3 may be any gaseous fuel having from one to four carbon atoms. Thus methane, ethane, propane or butane are the preferred fuels for the burner zone 3. However, any carbon fuel source commercially available whether liquid or gaseous can be employed provided that fuel-air mixture entering into the primary combustion zone 13 is in the gaseous state.

Suitable effluents which can be treated using the apparatus and method of the invention include any gaseous effluent containing oxidizable odorous constituents which are capable of undergoing combustion at atmospheric pressure in the presence of air. The contaminants which are susceptable to treatment include nitrogen containing hydrocarbons, particularly those having nitrogen fixed in a hydrocarbon ring structure, hydrocarbon mercaptan compounds, and carbonyl compounds. By carbonyl compounds it is meant any hydrocarbon containing an $> C = O$ group. The combustor is particularly suited for the decomposition of hydrogen sulfide.

The aforementioned suitable effluents are generally found to result from the processing of fossil fuel sources because the aforementioned contaminants occur in relatively large concentrations. In particular, the combustor has utility in replacing conventional flaring techniques to insure that odorous materials associated with the flare are completely eliminated. Particular examples of suitable process applications include the combustion of effluents that result from refining, petrochemical processing, coal gasification processes, production of sour gas wells, and underground storage of natural gas.

The combustor of the invention has particular usefulness in the above mentioned applications because the combustor is capable of operation over a wide range of flammability limits. Where materials which are in and of themselves non-combustible are found to be associated with the effluents, the combustor of this invention has been operated successfully in both laboratory and field conditions. Most often, the non-combustible material found in these effluents is water vapor. Moreover, due to downstream processing variables, the amount of water or other "inert" components has been found to fluctuate over relatively wide range.

An example of the above mentioned conditions is found in the most preferred embodiment of this invention, where the combustor is used to oxidize the effluent from a glycol dehydration unit associated with a natural gas well. Glycol dehydration units are used in the gas industry to eliminate moisture from the gas removed from underground storage or from an initial producing well. The glycol units employed in association with the gas wells include a system whereby glycol having absorbed concentrations of entrained water is passed to a still column wherein the glycol and water are heated to drive off the water. The regenerated glycol is then reused to dehydrate additional gas.

An example of a typical composition of the effluent from a still column on a glycol dehydration unit is natural gas 36 to 67%, glycol 0 to 0.02% water 36 to 67%, and H_2S 0.01 to 0.5%. Thus, the composition of the effluent fluctuates widely due to the nature of the producing well and the glycol dehydration process. This in turn causes a fluctuation in the flammability of the discharge effluent.

The conbustor of this invention has been found to successfully ignite and oxidize the effluent from glycol dehydration units under field test conditions, and to effectively eliminate the odor of hydrogen sulfide associated with the production of sour gas wells. Reasonable modifications of the aforementioned invention will be apparent to those skilled in the art.

We claim:

1. A lightweight, relatively inexpensive combustor comprising an elongated cylindrical stack open at the upstream end to allow entry of noxious odorous materials and at the downstream end to allow the burned gases to exit; an effluent combustion tube also open at each end and housed within said stack, said tube defining a primary burner zone and a secondary combustion zone and having openings formed therein at said secondary combustion zone for allowing the passage of air through said tube into said secondary combustion zone at an angle of approximately 90° to the flow of gases within said secondary combustion zone; burner means within said stack defining said primary burner zone and including means for injecting a combustible fuel and air into said primary burner zone to form a fuel-air mixture means for injecting air between said stack and said tube, said primary burner zone including an expansion zone wherein said fuel-air mixture is formed, a plurality of radially extending inclined swirl blades located in said burner means downstream from said expansion zone which impart a swirling motion to said fuel-air mixture as it flows through openings formed between said blades and, located immediately downstream from said swirl blades and immediately upstream from said secondary combustion zone, a primary combustion chamber in which said swirling fuel-air mixture is ignited and from which said ignited fuel-air mixture moves into said secondary combustion zone; and means for allowing said noxious odorous materials entering said upstream end of said stack to pass through said effluent combustion tube, around said primary burner zone, and into said secondary combustion zone wherein said noxious odorous materials ignite upon coming into contact with said ignited fuel-air mixture and are completely burned before exiting out said downstream end of said stack.

2. A combustor as defined in claim 1 and further characterized in that said openings in said effluent combustion tube are in the form of longitudinal slots extending from the end of said tube adjacent said primary burner zone to the opposite end of said tube.

3. A combustor as defined in claim 1 and further characterized in that said swirl blades are inclined 30° to 40° from the cross-sectional axis of said combustor and said openings formed between said blades extend across two-thirds to three-fourths of the radius of the primary combustion chamber.

4. A combustor as defined in claim 1 and further characterized in that a heat shield is attached to the end of said effluent combustion tube opposite said primary burner zone to protect said stack, said shield including means forming at least one aperture for the passage of air between said shield and said stack to cool said shield.

5. A combustor as defined in claim 1 and further characterized in that said stack has an opening formed therein near the downstream end of said secondary combustion zone to relieve pressure build-up and thereby prevent oscillatory combustion.

6. A combustor as defined in claim 1 and further characterized in that the means for injecting combustible fuel and air includes a nozzle having a restricted orifice which imparts high velocity to said fuel, said nozzle located upstream from said swirl blades.

* * * * *