

[54] **FUEL BURNER APPARATUS**

[75] Inventors: **Harold O. Ebeling; Russell D. Smith,**
both of Houston, Tex.

[73] Assignee: **Black, Sivalls, & Bryson, Inc.,**
Houston, Tex.

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[58] Field of Search 431/351, 173, 158, 352,
431/10; 110/28 F

[56] **References Cited**

UNITED STATES PATENTS

2,175,866	10/1939	Arnold.....	431/173
2,206,553	7/1940	Nagel.....	431/351 X
2,734,560	2/1956	Harris et al.....	431/351 X

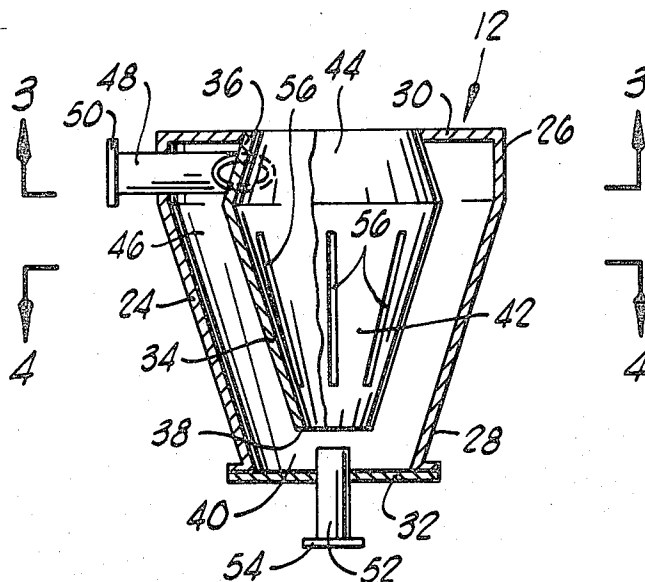
2,800,093	7/1957	Burg.....	431/173 X
3,200,870	8/1965	Hanley et al.....	431/173
3,265,113	8/1966	Thurley et al.....	431/238

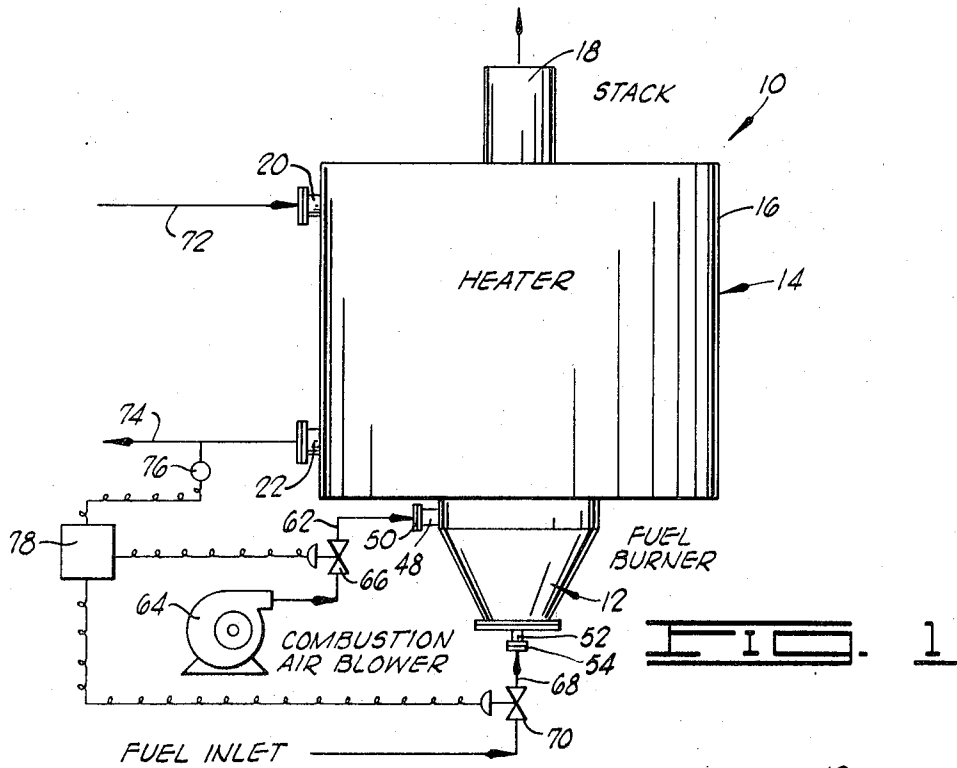
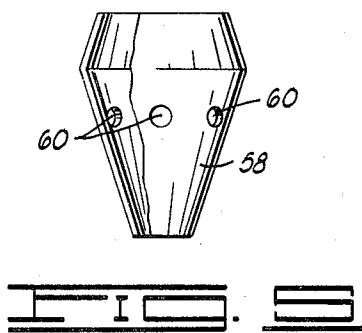
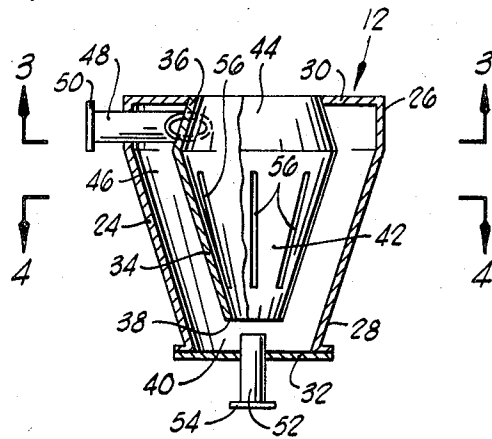
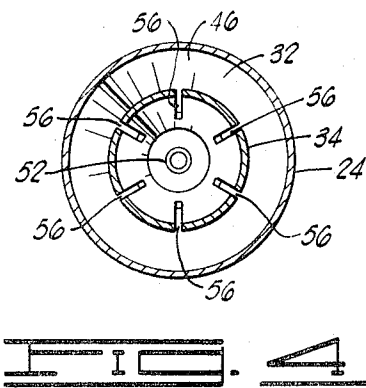
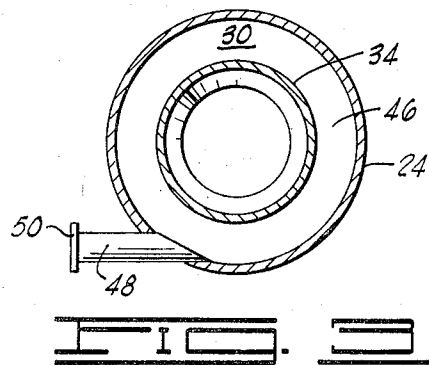
Primary Examiner—Edward G. Favors
Attorney, Agent, or Firm—C. Clark Dougherty, Jr.

[57] **ABSTRACT**

The present invention relates to an improved fuel burner apparatus which includes a hollow outer shell having a hollow inner liner supported therein so that an air passageway is formed between the inner liner and the outer shell and the interior of the inner liner forms a fuel-air combustion chamber. One or more openings are disposed in the inner liner so that a portion of combustion air flowing through the air passageway is admitted as secondary air directly into the interior of the inner liner.

9 Claims, 5 Drawing Figures





FUEL BURNER APPARATUS

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates generally to an improved fuel burner apparatus, and more particularly, but not by way of limitation, to an improved fuel burner apparatus of the type wherein combustion of the fuel takes place substantially within the burner structure.

2. Description of the Prior Art

A variety of types and designs of fuel burner apparatus have been developed and used in industrial applications. Fuel burner apparatus generally referred to as "high intensity burners" are particularly suitable for generating high velocity streams of hot combustion gases. This type of burner is characterized in that substantially all of the combustion process takes place and is confined within the burner apparatus. One such high intensity burner apparatus which does not require expensive refractory materials and which is particularly suitable for many industrial applications is described in detail in U.S. Pat. No. 3,265,113 assigned to the assignee of this present invention.

A problem common to all fuel burner apparatus utilized in industry is the formation of atmosphere polluting compounds in the combustion gases produced. For example, when a hydrocarbon fuel is burned with air, carbon monoxide and nitric oxide compounds are often formed in the combustion gases in quantities such that when the combustion gases are released to the atmosphere by way of stacks, etc., air pollution results. It has heretofore been recognized that the formation of carbon monoxide in the combustion gases produced when a hydrocarbon fuel is burned can be controlled within acceptable limits by controlling the combustion process. That is, in a fuel burner apparatus such as a high intensity burner wherein the fuel burns very quickly to produce a mixture of combustion products rich on carbon monoxide, the slow burning carbon monoxide can be eliminated by providing a secondary combustion zone in which the carbon monoxide is consumed, i.e., oxidized further to carbon dioxide.

The formation of nitric oxide compounds occurs after the burning of hydrocarbon fuel with air is completed. That is, nitrogen brought into the combustion process with the air combines with oxygen at the high temperatures at which the combustion gases exist after the primary combustion reaction of the hydrocarbon fuel is completed.

By the present invention an improved fuel burner apparatus is provided for burning a hydrocarbon fuel with air wherein carbon monoxide formed in the primary combustion reaction is consumed in a secondary combustion reaction but the formation of nitric oxide compounds in the secondary combustion reaction is minimized.

SUMMARY OF THE INVENTION

The present invention relates to an improved gas burner apparatus comprised of a closed outer shell having a hollow inner liner supported therein so that an air passageway is formed between the inner liner and the outer shell. The interior of the inner liner forms a combustion chamber and the open rearward end thereof forms a fuel-air mixing and ignition area within the rearward end of the outer shell. A combustion air inlet

is formed in the outer shell for admitting combustion air to the air passageway and to the fuel-air mixing and ignition area, and a fuel inlet is attached to the outer shell for admitting fuel to the fuel-air mixing and ignition area. The inner liner includes one or more openings positioned intermediate to the ends thereof so that a portion of combustion air flowing through the air passageway is caused to bypass the fuel-air mixing and ignition area and flow through the openings directly into the interior of the inner liner.

It is, therefore, a general object of the present invention to provide an improved fuel burner apparatus.

A further object of the present invention is the provision of an improved hydrocarbon fuel-air burner apparatus wherein the formation of nitric oxide compounds in the products of combustion is minimized.

Yet a further object of the present invention is the provision of an improved fuel burner apparatus wherein a hydrocarbon fuel can be combusted with air to produce a high velocity stream of hot combustion gases containing minimum quantities of carbon monoxide and nitric oxide compounds.

Other and further objects, features and advantages of the present invention will be evident from the following description of presently preferred embodiments when read in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a partially diagrammatic view of a heater system which includes a fuel burner apparatus of the present invention.

FIG. 2 is an enlarged side elevational view of the fuel burner apparatus of FIG. 1 shown in cross-section,

FIG. 3 is a cross-sectional view of the burner apparatus of FIG. 2 taken along line 3—3,

FIG. 4 is a cross-sectional view of the burner apparatus of FIG. 2 taken along line 4—4, and

FIG. 5 is a partly sectional view of an alternate form of inner liner which can be used in the fuel burner apparatus of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring now to the drawings, and particularly to FIG. 1, a heater system generally designated by the numeral 10 is shown which includes a fuel burner apparatus 12 of the present invention. The heater system 10 is conventional and includes a cabin type heat exchanger 14 arranged so that heat is exchanged between the high velocity stream of hot combustion gases produced by the fuel burner 12 and a process stream being heated. That is, the heat exchanger 14 includes an enclosure 16 having a conventional heating coil disposed therein (not shown) through which the process stream being heated is passed. Combustion gases produced by the burner 12 pass in heat exchange relationship with the heating coil and exit the heat exchanger enclosure 16 by way of a stack 18. The heating coil is connected through the enclosure 16 to inlet and outlet connections 20 and 22 respectively.

Referring now to FIGS. 2 through 4, the improved burner apparatus 12 of the present invention is illustrated in detail. The apparatus 12 basically comprises a hollow outer shell 24 having a forward end 26 and a rearward end 28. A front wall 30 is secured to the forward end 26 of the outer shell 24, and a rear wall 32

is secured to the rearward end 28 thereof. A hollow inner liner 34 is supported within the outer shell 24 with the forward end 36 thereof passing through and being attached to the forward wall 30, thereby forming an outlet for products of combustion exiting the burner apparatus 12. As will be understood, the interior of the inner liner 34 forms a combustion chamber within the apparatus 12. The open rearward end 38 of the inner liner 34 is spaced a distance from the rear wall 32 of the outer shell 24 so that a fuel-air mixing and ignition area 40 is provided within the rearward portion of the outer shell 24.

As best shown in FIG. 2, in order to promote recirculation of combustion gases within the burner 12, the inner liner 34 is preferably formed in a manner such that it includes a frusto-conically shaped rearward end portion 42 converging toward the rearward end 38 thereof, and a frusto-conically shaped forward portion 44 converging toward the forward end 36 thereof. The outer shell 24 is also preferably formed of a generally frusto-conical shape converging toward the rear end 28 thereof.

The inner liner 34 is positioned within the hollow outer shell 24 in a manner such that an air passageway 46 is formed between the inner liner and the outer shell. An air inlet 48 for admitting air to the air passageway 46 is formed in the outer shell 24 adjacent to the forward end 26 thereof. As shown in FIGS. 2 and 3, the air inlet 48 is comprised of a conduit having a conventional flange connection 50 at the outer end thereof and having the inner end passed through and sealingly attached such as by welding to the outer shell 24. Preferably, the air inlet 48 is arranged with respect to the outer shell 24 so that a volute shape results, i.e., the inlet 48 is positioned with respect to the shell 24 so that air passing through the inlet 48 enters the shell 24 tangentially and is caused to follow a generally helical path as it passes through the air passageway 46 to the fuel-air mixing and ignition area 40. As will be described further, this helical flow of air through the passageway 46 during the operation of the burner 12 keeps the inner liner 34 cool so that expensive refractory materials are not required and brings about mixing of the air with the fuel to be burned in the fuel-air mixing area 40.

A fuel inlet 52 is provided attached through the rear wall 32 of the outer shell 24 for injecting fuel into the fuel-air mixing and ignition area 40. The fuel inlet 52 is comprised of a conduit sealingly attached through the wall 32, having a conventional flange connection 54 at the outer end thereof and terminating open ended at a position between the rearward end 38 of the inner liner 34 and the rear wall 32.

The inner liner 34 includes a plurality of openings 56 formed therein. As shown in FIGS. 2 and 4, the openings are vertical slots which are positioned intermediate the ends 36 and 38 of the inner liner. It is to be understood, however, that the openings 56 may take a variety of shapes. For example, referring to FIG. 5, an alternate form of inner liner designated by the numeral 58 is illustrated. The liner 58 is identical to the liner 34 except that the openings 60 positioned therein are orifices of substantially circular shape. Other shaped openings in the inner liner may be utilized such as horizontal slots, slits, holes, etc.

Operation

Referring specifically to FIG. 1, the combustion gas outlet of the fuel burner apparatus 12, i.e., the open forward end 36 of the inner liner 34, is connected to the heat exchanger 14 of the heater system 10. The flange connection 50 of the air inlet 48 of the burner 12 is connected by a conduit 62 to a conventional air blower 64 and a conventional air flow control valve 66 is disposed in the conduit 62. The flange connection 54 of the fuel inlet 52 is connected by a conduit 68 to a source of fuel and a conventional fuel flow control valve 70 is disposed in the conduit 68.

The process stream being heated is conducted to the heater system 10 by way of a conduit 72 which is connected to the inlet connection 20 of the heating coil disposed in the heater enclosure 16, and the heated process stream is removed from the heating coil by way of a conduit 74 connected to the outlet connection 22. A conventional temperature transmitter 76 is disposed in the conduit 74 for sensing the temperature of the heated process stream, and a conventional flow ratio controller 78 is operably connected to the temperature transmitter 76. The flow ratio controller 78 is in turn operably connected to the air and fuel control valves 66 and 70 respectively.

In operation of the fuel burner 12 in conjunction with the system 10, air and fuel provided to the burner 12 by way of the conduits 62 and 68 respectively are mixed and burned within the burner as will be discussed further hereinbelow to produce a stream of hot combustion gases. The combustion gases are discharged within the heater enclosure 16 wherein they circulate around the heating coil disposed therein and then pass by way of the stack 18 into the atmosphere. The process fluid stream being heated flows through the heating coil disposed within the heater enclosure 16 in heat exchange relationship with the hot combustion gases flowing therein.

The flow ratio controller 78 senses the temperature (by way of the transmitter 76) of the process stream flowing through the conduit 74 and controls the flow rates of air and fuel to the burner apparatus 12 accordingly. That is, the flow ratio controller 78 controls the rate of air and fuel flowing to the burner 12 by operating the control valves 66 and 70 respectively in predetermined relationship to the temperature of the process stream exiting the heater system 10. In addition, the flow ratio controller 78 maintains the ratio of air to fuel flowing into the burner 12 at a preset level.

The foregoing description of the heater system 10 is given herein to illustrate a typical application in which the burner apparatus of the present invention can be utilized. It is to be understood, however, that the burner apparatus 12 can be utilized in any of a great variety of other applications and is not to be limited to the system described.

Referring now particularly to FIGS. 2 through 4, the combustion air entering the burner apparatus 12 by way of the air inlet connection 48 passes in a generally helical path through the air passageway 46 to the fuel-air mixing and ignition area 40 at the rearward end of the inner liner 34. Fuel flowing to the burner 12 by way of the fuel inlet connection 52 also enters the fuel-air mixing and ignition area 40. As the helical flow of combustion air reaches the mixing and ignition area 40, i.e., the end 38 of the inner liner 34, it changes directions

and extends into the internal portion of the inner liner. This change of direction generates an air vortex in the area 40 which brings about intimate mixing of the fuel and air. The resultant fuel-air mixing is ignited while in the area 40 and rapid burning of the fuel is completed within the interior of the inner liner 34 adjacent the rearward end 38 thereof. The rapid burnout of the fuel brings about the formation of carbon monoxide. However, the carbon monoxide formed is burned in a secondary combustion reaction which takes place as the products of combustion flow through and recirculate within the interior of the inner liner 34 prior to exiting the inner liner by way of the open forward end 36 thereof.

The openings 56 in the inner liner 34 cause a portion of the relatively cool combustion air passing through the air passageway 46 to bypass the fuel-air mixing and ignition area 40 and flow directly into the interior of the inner liner 34 as secondary air. This secondary air entering the combustion chamber portion of the burner 12 quenches the products of combustion to a temperature level below about 2,800°F but above a temperature of about 1,500°F so that the secondary burning of the carbon monoxide is completed but the formation of nitric oxide compounds is retarded. That is, since nitric oxide compounds do not form below a temperature level of about 2,800°F and since the carbon monoxide compounds formed are combusted to carbon dioxide at temperatures above about 1,500°F, by controlling the temperature of the combustion gases within the interior of the inner liner 34 at a level between about 1,500°F and 2,800°F the existence of both the compounds in the products of combustion is minimized. Stated another way, the burner apparatus 12 brings about primary combustion with excess fuel being present and controlled temperature secondary combustion by the addition of secondary combustion air to the interior of the inner liner 34 via the openings 56 thereby maintaining the formation of undesirable pollutants in the hot products of combustion produced at minimum levels.

As will be understood by those skilled in the art, the number, size and configuration of the openings 56 required in the inner liner 34 for a particular application can be determined by applying conventional engineering techniques. The rate of secondary combustion air which flows through the openings 56 depends on a number of factors such as the particular flow rate and pressure of the combustion air supplied to the burner 12 and the fuel-air ratio utilized as well as the number, size and shape of the openings 56.

As will be further understood by those skilled in the art, numerous changes can be made in the configuration and construction of the various parts of the apparatus 12 described herein. For example, the openings provided in the inner liner for causing secondary air to enter the combustion chamber of the burner 12 can take a variety of forms such as slots, slits, holes, etc. without departing from the spirit of the invention or the scope of the appended claims.

What is claimed is:

1. In a fuel burner apparatus having a closed outer shell; a hollow inner liner supported within the outer shell so that an air passageway is formed between the inner liner and the outer shell, the interior of the inner liner forming a fuel-air combustion chamber and the open rearward end thereof forming a fuel-air mixing

and ignition area within the rearward end of the outer shell; a combustion air inlet formed in the outer shell for admitting combustion air to said passageway and to said air-fuel mixing and ignition area; and a fuel inlet attached to the outer shell for admitting fuel to the fuel-air mixing area therewithin, the improvement which comprises:

said fuel inlet including a conduit positioned coaxially with said inner liner extending through the rearward end of said outer shell and terminating open-ended at a position between the rearward end of said inner liner and the rearward end of said outer shell; and

said inner liner including one or more openings positioned intermediate to the ends thereof so that a portion of combustion air flowing through said air passageway is caused by bypass said air-fuel mixing and ignition area and flow through said openings directly into the interior of said inner liner.

2. The burner apparatus of claim 1 wherein:

said inner liner is positioned coaxially with said outer shell and includes a frusto-conical section converging toward the rearward end thereof and a frusto-conical section converging toward the forward end thereof; and

said combustion air inlet forming a volute shape with the outer shell whereby the combustion air is caused to flow in a helical path within said air passageway.

3. An improved fuel burner apparatus which comprises:

a hollow outer shell having a forward end and a rearward end;

a front wall secured to the forward end of the outer shell thereby closing the forward end;

a rear wall secured to the rearward end of the outer shell thereby closing the rearward end;

a hollow inner liner having a forward end and a rearward end supported within the outer shell so that an air passageway is formed between the outer shell and the inner liner, the forward end of the inner liner extending through the front wall and the rearward end of the inner liner being spaced a predetermined distance from the rear wall, the inner liner including one or more openings therein positioned intermediate to the ends thereof so that a portion of combustion air flowing through said air passageway is caused to flow through said openings into the interior of the inner liner;

an air inlet formed in the outer shell adjacent the forward end thereof for admitting combustion air into said air passageway; and

a fuel inlet attached through said rear wall for injecting fuel into the outer shell at a position between the rear wall and the rearward end of the inner liner.

4. The burner apparatus of claim 3 wherein the inner liner includes a frusto-conical section converging toward the rearward end thereof and a frusto-conical section converging toward the forward end thereof.

5. The burner apparatus of claim 4 wherein said one or more openings in said inner liner are defined further as being elongated slots.

6. The burner apparatus of claim 4 wherein said one or more openings in said inner liner are defined further as being substantially circular shaped orifices.

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7. The apparatus of claim 4 wherein the outer shell is positioned coaxially with said inner liner and includes a frusto-conical section converging toward the rearward end thereof.

8. The burner apparatus of claim 7 wherein the air inlet formed in the outer shell forms a volute shape with the outer shell so that combustion air is caused to flow in a helical path within said air passageway.

9. The apparatus of claim 8 wherein the fuel gas inlet attached through said rear wall is a conduit positioned coaxially with the inner liner extending through the rear wall and terminating open-ended at a position between the rearward end of the inner liner and the rear wall.

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