FUEL NOZZLE FOR USE IN A BURNER

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Appl. No.: 12/564,369
Filed: Sep. 22, 2009

Related U.S. Application Data
Provisional application No. 61/099,200, filed on Sep. 22, 2008.

Publication Classification
Int. Cl.
F23D 14/62 (2006.01)
F23C 7/00 (2006.01)
U.S. Cl. 431/354; 431/187

ABSTRACT
A fuel nozzle for use in a burner comprises a main body having an inlet end and an outlet end and defining a longitudinal axis. A fuel passageway has a fuel receiving inlet, and a fuel emitting outlet for delivering fuel to a mixing chamber of the burner. A first air flow channel having an inlet, and an outlet disposed adjacent the fuel emitting outlet for delivering air to the mixing chamber. The portion of the first air flow channel adjacent the outlet is oriented obliquely to the longitudinal axis. A second air flow channel has an inlet, and an outlet disposed adjacent the fuel emitting outlet for delivering air to the mixing chamber. The first air flow channel and the second air flow channel generally surround the fuel passageway, and are disposed on the exterior of the main body.
FUEL NOZZLE FOR USE IN A BURNER

FIELD OF THE INVENTION

[0001] This application is a non-provisional application claiming priority to United States provisional patent application Ser. No. 61/099,200 filed on Sep. 22, 2008.

FIELD OF THE INVENTION

[0002] The present invention relates to fuel nozzles for use in burners, and more particularly to fuel nozzles for use in burners that mix air or oxygen with a gaseous or evaporated fuel.

BACKGROUND OF THE INVENTION

[0003] Burners that use gaseous fuel or liquid fuel are used in many applications including boilers, line heaters, furnaces, other gas fired appliances, and in many others. Basically, these burners introduce a gaseous fuel or liquid fuel into a stream of air or oxygen. If liquid fuel is used, it must be vapourized or atomized first. The resulting flow of fuel and air or oxygen is ignited and exits the nozzle of the burner either as a visible flame or as a stream of an extremely hot gaseous mixture.

[0004] In an attempt to improve the state of the art units in various applications, such as boilers, line heaters, furnaces, and other gas fired appliances, a detailed study was conducted to qualify and quantify the state of the art in each of these above stated fields. The study indicated that without exception, improvements could be made in each of these areas, especially in terms of reduction of operational costs, and reduction or elimination of emissions. In present world markets, operational costs and environmental concerns, such as reduction or elimination of emissions, are typically two of the most significant issues, if not the most significant issues faced by most businesses.

[0005] Interestingly, it is readily apparent in the prior art that the possible improvements that could be made to these various types of devices utilizing burners to produce heat, would not lead to a significantly improved end result. It is also readily apparent that, without exception, the fundamental problem in these various types of devices was that of burner inefficiency. Most prior art burners are only about 60% to 70% efficient. Inefficient combustion of fuel was the main problem inherent with all of these devices. Moreover, this problem of inefficiency of combustion is the major cause of the two above mentioned significant costs in business, namely operational costs and environmental concerns.

[0006] Accordingly, in order to fundamentally improve devices such as boilers, line heaters, furnaces, and other gas fired appliances, it has been found that it is necessary to make significant and primary advances in the design of the burners technology. More specifically, in order to maximize the design of boilers, line heaters, furnaces, and other gas fired appliances, in terms of cost, efficiency, and so on, it is necessary to fundamentally re-design the burners that power them. There is no sense in improving boiler technology, line heater technology, furnace technology, and so on, if the burners used in them are prohibitively inefficient.

[0007] It is interesting to note that such improvements to various types of burners have been attempted for many years in various areas without significant success. Accordingly, other types of improvements to burner systems and devices that employ burners are commonly used.

[0008] The most common design improvement used to overcome the environmental problem of emissions is to recirculate exhaust gases. In general, it has been found that recirculation of the exhaust gases can be used to decrease the overall emissions of a burner system. There are, however, problems associated with such recirculation of the exhaust gases. The most significant problem is that the recirculation of exhaust gases substantially increases the energy required for passing the mixture flow of combustion air and added exhaust gas through the system. For example, an increase of ten percent (10%) of exhaust gas recirculation from the exhaust back to the burner typically results in about a 40% to 45% increase in the required power of the fan that forces air into the burner system. Obviously, this is an attempt at a solution that is less than acceptable in terms of efficiency, and therefore cost. This is especially true considering most exhaust gases are passed through the burner system several times.

[0009] There are also burner systems that use energy from high velocity combustion air jets to promote recirculation within the burner system. The effectiveness of this technique depends on many factors, and typically it is more difficult to return a substantial portion of combustion products back to the burner if this technique is used, thus making it difficult to employ in many situations.

[0010] It is clear that recirculating exhaust gases in order to improve emissions is not a viable solution to improving the design of burner systems. Burning fuel as efficiently as possible with one pass through the burner system is the only sensible solution; however, desirably efficient burners do not exist.

[0011] Only a fundamental re-design of burners and burner technology will produce an efficient burner that produces low emissions. The fundamental technology of burners has not changed significantly in the last several decades. A search of the prior art has revealed two examples of burners that are known to be relatively effective in terms of efficiency and emissions, but not as efficient as the subsequently discussed present invention.

[0012] U.S. Pat. No. 7,484,956 issued Feb. 3, 2009, to Kobayashi et al., discloses Low NOx combustion using cogenerated oxygen and nitrogen streams. The combustion of hydrocarbon fuel is achieved with less formation of NOx from feeding the fuel into a slightly oxygen-enriched atmosphere, and separating air into oxygen-rich and nitrogen-rich streams which are fed separately into the combustion device.

[0013] U.S. Pat. No. 7,429,173 issued Sep, 30, 2008, to Lanary et al., discloses a gas burner for use in a furnace and a method of burning gas in a furnace, especially but not exclusively a process furnace used in an oil cracking or refining process. The gas burner comprises two passageways with adjacent outlets. The first passageway is in fluid communication with a source of pressurised fuel gas and has an aperture through which recirculated flue gas can enter the first passageway and the second passageway is in fluid communication with a source of air. In operation, fuel gas is injected into the first passageway and recirculated flue gas is thereby drawn into the first passageway so that it mixes with the fuel gas. Fuel gas is partially combusted and a mixture of partially combusted fuel gas and recirculated flue gas flows up the first passageway and comes into contact with air from the second passageway and combusts. The use of recirculated flue gas keeps down the level of NOx emissions and as the recircu-
lated flue gas is sucked into the first passageway by the pressurised fuel gas flow, it is not necessary to provide complex pumping mechanisms.

[0014] U.S. Pat. No. 7,422,427 issued Sep. 9, 2008, to Lifshitz, discloses an Energy Efficient Low NOx Burner and Method of Operating Same. The burner is for installation in a furnace having a mixing chamber defined by at least a furnace front wall, two side walls, a top wall and a bottom wall as well as heat transfer pipes through which a heat transfer medium flows and which are arranged on at least one of the top, bottom and side walls. The burner assembly is mounted to the furnace front wall and has a tubular member with an open distal end that is located inside the mixing chamber. The other end of the tubular member is attached to the front wall. Several combustion air ports extend into the tubular member from the other proximal end thereof and are coupled to a source of combustion air. Several fuel gas discharge nozzles also extend into the tubular member from the other end thereof and are coupled to a fuel source. Furnace gas openings formed in the tubular member are spaced apart from the distal end, are arranged about the tubular member’s periphery, and are located relative to the mixing chamber so that furnace gases circulate past some of the heat transfer pipes before they reach the furnace gas openings to thereby form a mixture of combustion air, fuel gas and furnace gas. A spinner at the distal end of the tubular member creates a recirculation zone for the mixture downstream of the spinner and the tubular member.

[0015] U.S. Pat. No. 6,485,289 issued Nov. 26, 2002, to Kelly, et al., discloses an Ultra Reduced NOx Burner System and Process. Fuel Modification Fuel Rich Reactor (FMRR) zone gases are brought together with products from a Fuel Lean Reactor (FMR) zone in a low temperature burner and NOx reduction reactor zone. The fuel modification fuel rich reactor stabilizes combustion through recirculation of hot gases to the reactants. Nitrogen species decay reactions in the fuel rich zone controls the production of NOx. The nitrogen species from the fuel rich zone and the NOx from the fuel lean zone react in the burner zone at an optimal temperature and nitrogen species mix where NO is minimized. Temperature in all zones, and in particular the burner zone, can be controlled by furnace gas entrainment, induced flue gas recirculation, forced flue gas recirculation and active cooling by radiative and/or convective heat transfer. NOx can be even further reduced by introducing ammonia, or a like amine species, into the low temperature burner zone. By balancing combustion and emissions control reactions over several zones, low emissions can be achieved under good flame stability, turndown, heat transfer and noise characteristics.

[0017] It is an object of the present invention to provide a fuel nozzle for use in a burner, wherein the fuel nozzle causes the burner to burn fuel very efficiently.

[0018] It is another object of the present invention to provide a fuel nozzle for use in a burner, wherein the fuel nozzle causes the burner to produce minimal unwanted emissions.

[0019] It is a further object of the present invention to provide a fuel nozzle for use in a burner, wherein the fuel nozzle and burner can be used with various types of gaseous and liquid fuels.

[0020] It is a further object of the present invention to provide a fuel nozzle for use in a burner, wherein the fuel nozzle and burner are cost effective.

SUMMARY OF THE INVENTION

[0021] In accordance with one aspect of the present invention there is disclosed a novel fuel nozzle for use in a burner. The fuel nozzle comprises a main body having an inlet end and an outlet end and defining a longitudinal axis extending between the inlet end and the outlet end. A fuel passageway has a fuel receiving inlet, and a fuel emitting outlet for delivering fuel to a mixing chamber of the burner. A first air flow channel has an inlet, and an outlet disposed adjacent the fuel emitting outlet for delivering air to the mixing chamber. The portion of the first air flow channel adjacent the outlet is oriented obliquely to the longitudinal axis.

[0022] In accordance with another aspect of the present invention there is disclosed a novel fuel nozzle for use in a burner. The fuel nozzle comprises a main body having an inlet end and an outlet end and defining a longitudinal axis extending between the inlet end and the outlet end. A fuel passageway has a fuel receiving inlet, and a fuel emitting outlet for delivering fuel to a mixing chamber of the burner. A first air flow channel is disposed on the exterior of the elongate main body, and has an inlet, and an outlet disposed adjacent the fuel emitting outlet for delivering air to the mixing chamber.

[0023] In accordance with yet another aspect of the present invention there is disclosed a novel fuel nozzle for use in a burner. The fuel nozzle comprises a main body having an inlet end and an outlet end and defining a longitudinal axis extending between the inlet end and the outlet end. A fuel passageway has a fuel receiving inlet, and a fuel emitting outlet for delivering fuel to a mixing chamber of the burner. A first air flow channel has an inlet, and an outlet disposed adjacent the fuel emitting outlet for delivering air to the mixing chamber. A second air flow channel has an inlet, and an outlet disposed adjacent the fuel emitting outlet for delivering air to the mixing chamber. The first air flow channel and the second air flow channel generally surround the fuel passageway.

[0024] Other advantages, features and characteristics of the present invention, as well as methods of operation and functions of the related elements of the structure, and the combination of parts and economies of manufacture, will become more apparent upon consideration of the following detailed description and the appended claims with reference to the accompanying drawings, the latter of which is briefly described herein below.

BRIEF DESCRIPTION OF THE DRAWINGS

[0025] The novel features which are believed to be characteristic of the fuel nozzle according to the present invention, as to its structure, organization, use and method of operation, together with further objectives and advantages thereof, will be better understood from the following drawings in which a presently preferred embodiment of the invention will now be illustrated by way of example. It is expressly understood, however, that the drawings are for the purpose of illustration and description only, and are not intended as a definition of the limits of the invention. In the accompanying drawings:

[0026] FIG. 1 is a sectional side elevational view of the first preferred embodiment of the fuel nozzle according to the present invention, installed in a burner;

[0027] FIG. 2 is a perspective view of the first preferred embodiment of the fuel nozzle according to the present invention, as shown in FIG. 1;

[0028] FIG. 3 is a side elevational view of the fuel nozzle of FIG. 2;

[0029] FIG. 4 is a front elevational view of the fuel nozzle of FIG. 2;

[0030] FIG. 5 is a rear elevational view of the fuel nozzle of FIG. 2;
FIG. 6 is a sectional side elevational view of the fuel nozzle of FIG. 2, taken along section line 6-6 of FIG. 5;

FIG. 7 is a side elevational view of a second preferred embodiment of the fuel nozzle according to the present invention; and,

FIG. 8 is a sectional side elevational view similar to FIG. 7, but with the nozzle tip removed from the nozzle body.

**DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS**

Referring to FIGS. 1 through 8 of the drawings, it will be noted that FIGS. 1 through 6 are directed to a first preferred embodiment of the fuel nozzle according to the present invention, and FIGS. 7 and 8 are directed to a second preferred embodiment of the fuel nozzle according to the present invention.

Reference will now be made to FIGS. 1 through 6, which show a first preferred embodiment of the fuel nozzle according to the present invention, as indicated by general reference numeral 50, for use in a burner 20, such as the burner 20 shown in FIG. 1. It should be understood that for the sake of convenience, the term air is used to describe air received from a pressurized or compressed source of air that also oxygen from a pressurized or compressed source of oxygen could be used. If a source of air is used, the oxygen in the air is reacted with a fuel such as propane, natural gas, and so on. The nitrogen in the air is merely separated from the oxygen upon combustion. It is also contemplated that hydrogen could be used along with the oxygen.

The substantially straight fuel nozzle 50 comprises an elongate main body 55 having an inlet end 56 and an outlet end 57, and is substantially circular in cross-section. The main body 55 defines a longitudinal axis “L” extending between the inlet end 56 and the outlet end 57.

The fuel nozzle 50 has a substantially straight fuel passageway 58 centrally disposed in the elongate main body 55. The substantially straight fuel passageway 58 has a fuel receiving inlet 53 and a fuel emitting outlet 54 for delivering fuel to a mixing chamber 80 of the burner 20, by passing a flow of fuel from the fuel receiving inlet 53 to the fuel emitting outlet 54. In the first preferred embodiment, as illustrated, the fuel emitting outlet 54 actually comprises a first fuel emitting outlet 54a, a second fuel emitting outlet 54b, a third fuel emitting outlet 54c, a fourth fuel emitting outlet 54d, a fifth fuel emitting outlet 54e, and a sixth fuel emitting outlet 54f. The first fuel emitting outlet 54a, the second fuel emitting outlet 54b, the third fuel emitting outlet 54c, the fourth fuel emitting outlet 54d, the fifth fuel emitting outlet 54e, and the sixth fuel emitting outlet 54f are each oriented at an angle of about ten degrees with respect to the longitudinal axis “L”, which has been found to disperse the fuel fully for ready evaporation by the air. Any other suitable angle may alternatively be used.

Preferably, the elongate main body 55 comprises a narrow back portion 55a having a circular cross-section, a wider front portion 55b having a circular cross-section, and a sloped portion 55c interconnecting the narrow back portion 55a and the wider front portion 55b. The fuel receiving inlet 53 is disposed at the inlet end 56 and the fuel emitting outlet 54 is disposed at the outlet end 57. The sloped portion 55c of the fuel nozzle 50 engages in sealing contact with a cooperating receiving surface 21 on the main body of the burner 20. There is also a stepped nozzle fitting portion 59 on the fuel passageway 58 at the inlet end 56 of the main body 55.

The fuel nozzle 50 also comprises an external rear portion 51 that projects rearwardly from the back end 26 of the main body 22 of the burner 20. Preferably, the external rear portion 51 of the fuel nozzle 50 is threaded to accept a co-operating nut 52 thereon, to thereby retain the fuel nozzle 50 in place in the main body 22.

In order to permit air flow from a source of compressed air (not specifically shown) to the mixing chamber 80 of the burner 20, there is a first air flow channel 90a, a second air flow channel 90b, a third air flow channel 90c, a fourth air flow channel 90d, and a fifth air flow channel 90e. It has been found that it is preferable to have this number of air flow channels for the purpose of even air flow and distribution there are two or more air flow channels 90. Any suitable number of air flow channels 90 could be used depending on the specific application of the burner 20, the size of the burner 20 and the fuel nozzle 50, and so on. Various fuel nozzles according to the present invention have been tried, including from two air flow channels 90 on up. It has been found that each specific number of air flow channels might have its own advantages and disadvantages.

Each of the first, second, third, fourth and fifth air flow channels 90a, 90b, 90c, 90d, 90e has an inlet 91, and an outlet 92 disposed adjacent the fuel emitting outlet 54 for delivering air to the mixing chamber 80 of the burner 20. As can be readily seen in the figures, the portion 93 of each of the first air flow channel 90a, the second air flow channel 90b, the third air flow channel 90c, the fourth air flow channel 90d, and the fifth air flow channel 90e adjacent the outlet that air flow channel is oriented obliquely to the longitudinal axis “L.” More specifically, substantially all of the first air flow channel 90a, the second air flow channel 90b, the third air flow channel 90c, the fourth air flow channel 90d, and the fifth air flow channel 90e is helically shaped. Each of the plurality of helically shaped air flow channels 90 is substantially parallel to adjacent helically shaped air flow channels 90. The helically shaped air flow channels 90 are preferably disposed on the exterior of the fuel nozzle 50.

The inlet 91 of the first air flow channel 90a has a cross-sectional area that is greater than the cross-sectional area of the outlet 92 of the same first air flow channel 90a; the inlet 91 of the second air flow channel 90b has a cross-sectional area that is greater than the cross-sectional area of the outlet 92 of the same second air flow channel 90b; the inlet 91 of the third air flow channel 90c has a cross-sectional area that is greater than the cross-sectional area of the outlet 92 of the same third air flow channel 90c; the inlet 91 of the fourth air flow channel 90d has a cross-sectional area that is greater than the cross-sectional area of the outlet 92 of the same fourth air flow channel 90d; the inlet 91 of the fifth air flow channel 90e has a cross-sectional area that is greater than the cross-sectional area of the outlet 92 of the same fifth air flow channel 90e. Preferably, the cross-sectional area of each of the inlets 91 are the same one as the other and cross-sectional area of each of the outlets 92 are the same one as the other.

Further, the ratio of the cross-sectional area of the inlet 91 of the first air flow channel 90a to the cross-sectional area of the outlet 92 of the same first air flow channel 90a is about 1.6 to 1; the ratio of the cross-sectional area of the inlet 91 of the second air flow channel 90b to the cross-sectional area of the outlet 92 of the same second air flow channel 90b is about 1.6 to 1; the ratio of the cross-sectional area of the inlet 91 of the third air flow channel 90c to the cross-sectional area of the outlet 92 of the same third air flow channel 90c is about 1.6 to 1; the ratio of the cross-sectional area of the inlet 91 of the fourth air flow channel 90d to the cross-sectional area of the outlet 92 of the same fourth air flow channel 90d is about 1.6 to 1; and the ratio of the cross-sectional area of the inlet 91 of the fifth air flow channel 90e to the cross-sectional area of the outlet 92 of the same fifth air flow channel 90e is about 1.6 to 1.
area of the outlet 92 of the same second air flow channel 90b is also about 1.6 to 1; the ratio of the cross-sectional area of the inlet 91 of the third air flow channel 90c to the cross-sectional area of the outlet 92 of the same third air flow channel 90c is also about 1.6 to 1; the ratio of the cross-sectional area of the inlet 91 of the fourth air flow channel 90d to the cross-sectional area of the outlet 92 of the same fourth air flow channel 90d is also about 1.6 to 1; and the ratio of the cross-sectional area of the inlet 91 of the fifth air flow channel 90e to the cross-sectional area of the outlet 92 of the same fifth air flow channel 90e is also about 1.6 to 1.

[0044] It has been found that the ratio of about 1.6 to 1 can be more accurately expressed as the golden ratio, also known as the golden number, which is often denoted by the Greek letter PHI (q) and is determined by the mathematical expression (1+sqrt(5))/2, which is approximately equal to 1.618033987.

[0045] Further, it is preferable that the cross-sectional area of each of the five air flow channels 90 decreases from the inlet 91 to the outlet 92. More specifically, it is also preferable that the width of each of the five air flow channels 90 decreases from the inlet 91 to the outlet 92, for ease of manufacturing, while the depth remains constant. It is quite permissible for the depth of the five air flow channels 90 to also decrease from the inlet 91 to the outlet 92, either additionally to the decrease in width of the channels 90, or instead of the decrease in width of the channels 90.

[0046] As can be best seen in FIG. 1, the wider front portion 55b of the fuel nozzle 50 contacts the constant cross-section front portion 24 of the burner 20 in sealed relation. Accordingly, air must pass through the helically shaped air flow channels 90 in order to reach the mixing chamber 80.

[0047] In use, with reference to FIG. 1, air within the burner 20 must pass through the first air flow channel 90a, the second air flow channel 90b, the third air flow channel 90c, the fourth air flow channel 90d, and the fifth air flow channel 90e immediately before being emitted to the mixing chamber 80 of the burner 20. The fast flow of air then passes by the outlet end 57 of the elongate main body 55 of the substantially straight fuel nozzle 50 and past the fuel nozzle tip 60, to then mix with the fuel emanating from the fuel nozzle tip 60.

[0048] Due to the fact that the first air flow channel 90a, the second air flow channel 90b, the third air flow channel 90c, the fourth air flow channel 90d, and the fifth air flow channel 90e are all helically shaped, the air exiting the outlets 92 of each of these five air flow channels 90 travels in a first swirling helical pattern along the mixing chamber 80 towards the combustion chamber 82. The swirling of the air in the combustion chamber 82 provides for a substantially lengthened path of travel for the air within the combustion chamber 82, as compared to the actual length of the combustion chamber 82. In this manner, there is a significantly longer dwell time for the air, and also the fuel that the air has “picked up”. Accordingly, there is a significantly lengthy time for combustion to occur, and therefore heat generation to occur, and therefore a significant amount of time for heat transfer to occur from the combustion chamber 82, through the combustion chamber tube 84, and to the ambient surroundings, where the heat is delivered to a desired destination. In tests, it has been found that flame temperature of the burner 20 of the present invention can readily be in excess of 2000 degrees, and produce a stack temperature of about 2000 degrees Fahrenheit which is a drop of 1000 degrees Fahrenheit that has gone into elevating the temperature of the object to be heated. Typically, in prior art burners, there is a flame temperature of about 1600 degrees Fahrenheit and a stack temperature of about 800 degrees Fahrenheit which transfer to only 800 degrees temperature difference that is used to heat an object.

[0049] Reference will now be made to FIGS. 7 and 8, which show a second preferred embodiment of the fuel nozzle according to the present invention, as indicated by the general reference numeral 250. The second preferred embodiment of the fuel nozzle 250 is similar to the first preferred embodiment of the fuel nozzle 50 except that the fuel nozzle 250 further comprises a fuel nozzle tip 260 mounted in removable and replaceable relation in the outlet end 257 of the elongate main body 255 of the fuel nozzle 250. The fuel nozzle tip 260 is mounted in removable and replaceable relation as described, to permit ready replacement of the fuel nozzle tip 260 in the event of damage, and also to permit selection of an appropriate fuel nozzle tip 260 for an end application, such as placement in a boiler, line heater, or furnace.

[0050] As can be understood from the above description and from the accompanying drawings, the present invention provides a fuel nozzle that causes a burner to burn fuel very efficiently, that produces minimal unwanted emissions, that can be used with various types of gaseous and liquid fuel, and that is cost effective, all of which features are unknown in the prior art.

[0051] Other variations of the above principles will be apparent to those who are knowledgeable in the field of the invention, and such variations are considered to be within the scope of the present invention. Further, other modifications and alterations may be used in the design and manufacture of the fuel nozzle of the present invention without departing from the spirit and scope of the accompanying claims.

We claim:

1. A fuel nozzle for use in a burner, said fuel nozzle comprising:
   a main body having an inlet end and an outlet end and defining a longitudinal axis extending between said inlet end and said outlet end;
   a fuel passageway having a fuel receiving inlet, and a fuel emitting outlet for delivering fuel to a mixing chamber of said burner and;
   a first air flow channel having an inlet, and an outlet disposed adjacent said fuel emitting outlet for delivering air to said mixing chamber;
   wherein the portion of said first air flow channel adjacent said outlet is oriented obliquely to said longitudinal axis.

2. The fuel nozzle of claim 1, wherein said main body comprises an elongate main body.

3. The fuel nozzle of claim 2, wherein said elongate main body is circular in cross-section.

4. The fuel nozzle of claim 1, wherein said fuel passageway is a central fuel passageway.

5. The fuel nozzle of claim 4, wherein said fuel nozzle is substantially straight.

6. The fuel nozzle of claim 5, wherein said central passageway is substantially straight.

7. The burner of claim 1, wherein substantially all of said first air flow channel is oriented obliquely to said longitudinal axis.

8. The burner of claim 7, wherein said first air flow channel is helically shaped.

9. The burner of claim 1, wherein said inlet of said first air flow channel has a cross-sectional area that is larger than the cross-sectional area of said outlet of said first air flow channel.
10. The burner of claim 6, wherein the ratio of the cross-sectional area of said inlet of said first air flow channel to the cross-sectional area of said outlet of said first air flow channel is about 1.6 to 1.

11. The burner of claim 10, wherein the cross-sectional area of said first air flow channel decreases from said inlet to said outlet.

12. The burner of claim 11, wherein the width of said first air flow channel decreases from said inlet to said outlet.

13. The burner of claim 12, wherein the depth of said first air flow channel decreases from said inlet to said outlet.

14. The fuel nozzle of claim 13, further comprising a second air flow channel having an inlet, and an outlet disposed adjacent said fuel emitting outlet for delivering air to said mixing chamber.

15. The fuel nozzle of claim 14, further comprising a third air flow channel having an inlet, and an outlet disposed adjacent said fuel emitting outlet for delivering air to said mixing chamber, a fourth air flow channel having an inlet, and an outlet disposed adjacent said fuel emitting outlet for delivering air to said mixing chamber, and a fifth air flow channel having an inlet, and an outlet disposed adjacent said fuel emitting outlet for delivering air to said mixing chamber.

16. The fuel nozzle of claim 15, wherein said plurality of helically shaped air flow channels is substantially parallel to adjacent helically shaped air flow channels.

17. The fuel nozzle of claim 16, wherein said second air flow channel, said third air flow channel, said fourth air flow channel, and said fifth air flow channel are each helically shaped.

18. The fuel nozzle of claim 2, wherein said elongate main body comprises a narrow back portion and a wider front portion.

19. The fuel nozzle of claim 18, wherein said elongate main body further comprises a sloped portion interconnecting said narrow back portion and said wider front portion.

20. The burner of claim 19, wherein said sloped portion of said fuel nozzle engages in sealing contact with a co-operating receiving surface on said burner.

21. The burner of claim 18, wherein said fuel nozzle comprises a rear portion that is threaded to engage a co-operating nut to thereby retain said fuel nozzle in place on said burner.

22. The fuel nozzle of claim 1, further comprising a fuel nozzle tip mounted in removable and replaceable relation in the front end of said main body.

23. A fuel nozzle for use in a burner, said fuel nozzle comprising:

a main body having an inlet end and an outlet end and defining a longitudinal axis extending between said inlet end and said outlet end;

a fuel passageway having a fuel receiving inlet, and a fuel emitting outlet for delivering fuel to a mixing chamber of said burner; and,

a first air flow channel disposed on the exterior of said elongate main body, and having an inlet, and an outlet disposed adjacent said fuel emitting outlet for delivering air to said mixing chamber.

24. The fuel nozzle of claim 23, wherein said main body comprises an elongate main body.

25. The fuel nozzle of claim 24, wherein said elongate main body is circular in cross-section.

26. The fuel nozzle of claim 23, wherein said fuel passageway is a central fuel passageway.

27. The fuel nozzle of claim 26, wherein said fuel nozzle is substantially straight.

28. The fuel nozzle of claim 27, wherein said central passageway is substantially straight.

29. The burner of claim 23, wherein substantially all of said first air flow channel is oriented obliquely to said longitudinal axis.

30. The burner of claim 29, wherein said first air flow channel is helically shaped.

31. The burner of claim 23, wherein said inlet of said first air flow channel has a cross-sectional area that is larger than the cross-sectional area of said outlet of said first air flow channel.

32. The burner of claim 28, wherein the ratio of the cross-sectional area of said inlet of said first air flow channel to the cross-sectional area of said outlet of said first air flow channel is about 1.6 to 1.

33. The burner of claim 32, wherein the cross-sectional area of said first air flow channel decreases from said inlet to said outlet.

34. The burner of claim 33, wherein the width of said first air flow channel decreases from said inlet to said outlet.

35. The burner of claim 34, wherein the depth of said first air flow channel decreases from said inlet to said outlet.

36. The fuel nozzle of claim 35, further comprising a second air flow channel having an inlet, and an outlet disposed adjacent said fuel emitting outlet for delivering air to said mixing chamber.

37. The fuel nozzle of claim 36, further comprising a third air flow channel having an inlet, and an outlet disposed adjacent said fuel emitting outlet for delivering air to said mixing chamber, a fourth air flow channel having an inlet, and an outlet disposed adjacent said fuel emitting outlet for delivering air to said mixing chamber, and a fifth air flow channel having an inlet, and an outlet disposed adjacent said fuel emitting outlet for delivering air to said mixing chamber.

38. The fuel nozzle of claim 37, wherein said plurality of helically shaped air flow channels is substantially parallel to adjacent helically shaped air flow channels.

39. The fuel nozzle of claim 38, wherein said second air flow channel, said third air flow channel, said fourth air flow channel, and said fifth air flow channel are each helically shaped.

40. The fuel nozzle of claim 24, wherein said elongate main body comprises a narrow back portion and a wider front portion.

41. The fuel nozzle of claim 40, wherein said elongate main body further comprises a sloped portion interconnecting said narrow back portion and said wider front portion.

42. The burner of claim 41, wherein said sloped portion of said fuel nozzle engages in sealing contact with a co-operating receiving surface on said burner.

43. The burner of claim 40, wherein said fuel nozzle comprises a rear portion that is threaded to engage a co-operating nut to thereby retain said fuel nozzle in place on said burner.

44. The fuel nozzle of claim 23, further comprising a fuel nozzle tip mounted in removable and replaceable relation in the front end of said main body.

45. A fuel nozzle for use in a burner, said fuel nozzle comprising:

a main body having an inlet end and an outlet end and defining a longitudinal axis extending between said inlet end and said outlet end;
a fuel passageway having a fuel receiving inlet, and a fuel emitting outlet for delivering fuel to a mixing chamber of said burner;
a first air flow channel having an inlet, and an outlet disposed adjacent said fuel emitting outlet for delivering air to said mixing chamber; and,
a second air flow channel having an inlet, and an outlet disposed adjacent said fuel emitting outlet for delivering air to said mixing chamber;
wherein said first air flow channel and said second air flow channel generally surround said fuel passageway.
46. The fuel nozzle of claim 45, wherein said main body comprises an elongate main body.
47. The fuel nozzle of claim 46, wherein said elongate main body is circular in cross-section.
48. The fuel nozzle of claim 45, wherein said fuel passageway is a central fuel passageway.
49. The fuel nozzle of claim 48, wherein said fuel nozzle is substantially straight.
50. The fuel nozzle of claim 49, wherein said central passageway is substantially straight.
51. The burner of claim 45, wherein substantially all of said first air flow channel is oriented obliquely to said longitudinal axis.
52. The burner of claim 51, wherein said first air flow channel is helically shaped.
53. The burner of claim 45, wherein said inlet of said first air flow channel has a cross-sectional area that is larger than the cross-sectional area of said outlet of said first air flow channel.
54. The burner of claim 50, wherein the ratio of the cross-sectional area of said inlet of said first air flow channel to the cross-sectional area of said outlet of said first air flow channel is about 1.6 to 1.
55. The burner of claim 54, wherein the cross-sectional area of said first air flow channel decreases from said inlet to said outlet.
56. The burner of claim 55, wherein the width of said first air flow channel decreases from said inlet to said outlet.
57. The burner of claim 56, wherein the depth of said first air flow channel decreases from said inlet to said outlet.
58. The fuel nozzle of claim 57, further comprising a second air flow channel having an inlet, and an outlet disposed adjacent said fuel emitting outlet for delivering air to said mixing chamber.
59. The fuel nozzle of claim 58, further comprising a third air flow channel having an inlet, and an outlet disposed adjacent said fuel emitting outlet for delivering air to said mixing chamber, a fourth air flow channel having an inlet, and an outlet disposed adjacent said fuel emitting outlet for delivering air to said mixing chamber, and a fifth air flow channel having an inlet, and an outlet disposed adjacent said fuel emitting outlet for delivering air to said mixing chamber.
60. The fuel nozzle of claim 59, wherein said plurality of helically shaped air flow channels is substantially parallel to adjacent helically shaped air flow channels.
61. The fuel nozzle of claim 60, wherein said second air flow channel, said third air flow channel, said fourth air flow channel, and said fifth air flow channel are each helically shaped.
62. The fuel nozzle of claim 46, wherein said elongate main body comprises a narrow back portion and a wider front portion.
63. The fuel nozzle of claim 62, wherein said elongate main body further comprises a sloped portion interconnecting said narrow back portion and said wider front portion.
64. The burner of claim 19, wherein said sloped portion of said fuel nozzle engages in sealing contact with a co-operating receiving surface on said burner.
65. The burner of claim 18, wherein said fuel nozzle comprises a rear portion that is threaded to engage a co-operating nut to thereby retain said fuel nozzle in place on said burner.
66. The fuel nozzle of claim 1, further comprising a fuel nozzle tip mounted in removable and replaceable relation in the front end of said main body.

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