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(54) **BURNER WITH FLAME POSITION ELECTRODE ARRAY**

(71) Applicant: **ClearSign Combustion Corporation**, Seattle, WA (US)

(72) Inventors: **Joseph Colannino**, Bellevue, WA (US); **Robert E. Breidenthal**, Seattle, WA (US); **Igor A. Krichtafovitch**, Kirkland, WA (US); **Christopher A. Wiklof**, Everett, WA (US)

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(57) **ABSTRACT**

A burner includes a flame positioning mechanism. The flame positioning mechanism includes a flame charger, a plurality of electrodes placed a respective distances along a fuel stream propagation path, and an electrode switch configured to place a subset of the plurality of electrodes into electrical continuity with a holding voltage. Current flow between the flame charge and the holding voltage anchors the flame to an electrode placed into electrical continuity with the holding voltage.

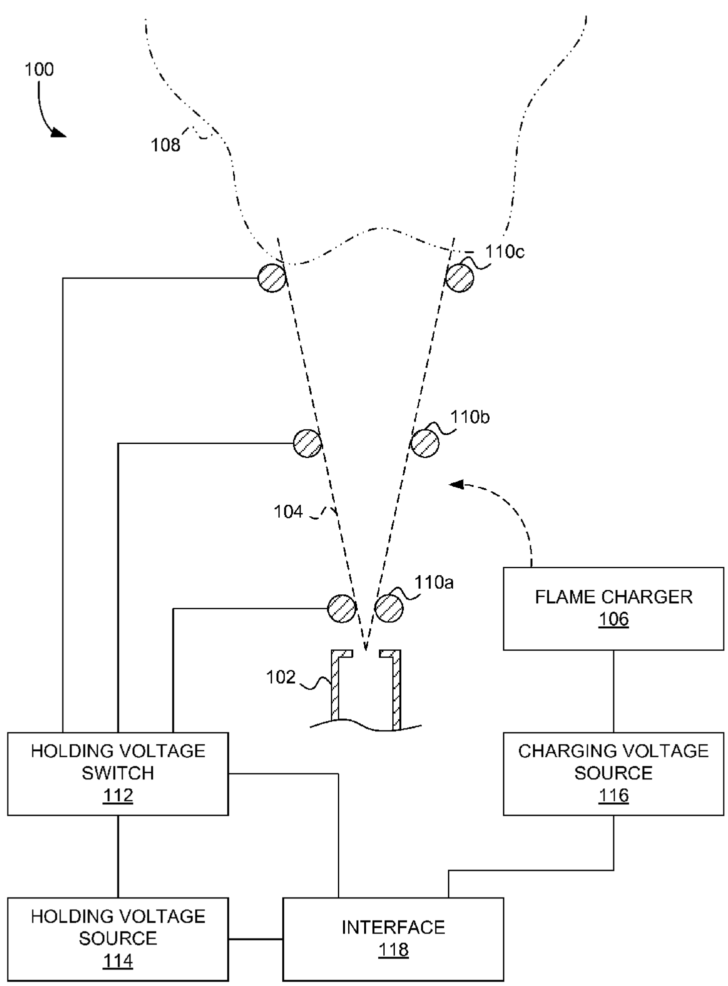
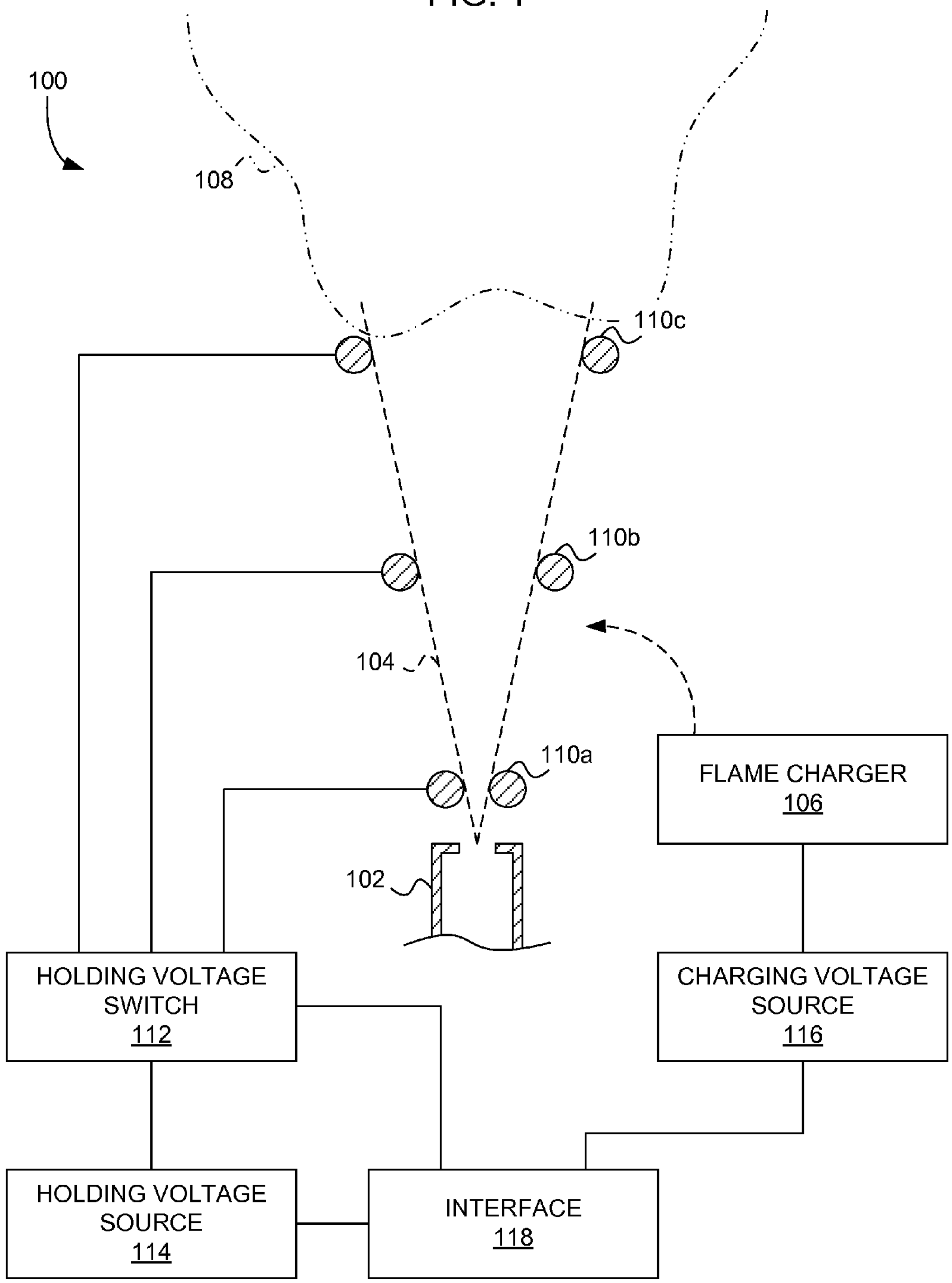


FIG. 1



100
108
110c
110b
104
110a
102
FLAME CHARGER
106
HOLDING VOLTAGE SWITCH
112
CHARGING VOLTAGE SOURCE
116
HOLDING VOLTAGE SOURCE
114
INTERFACE
118

FIG. 2

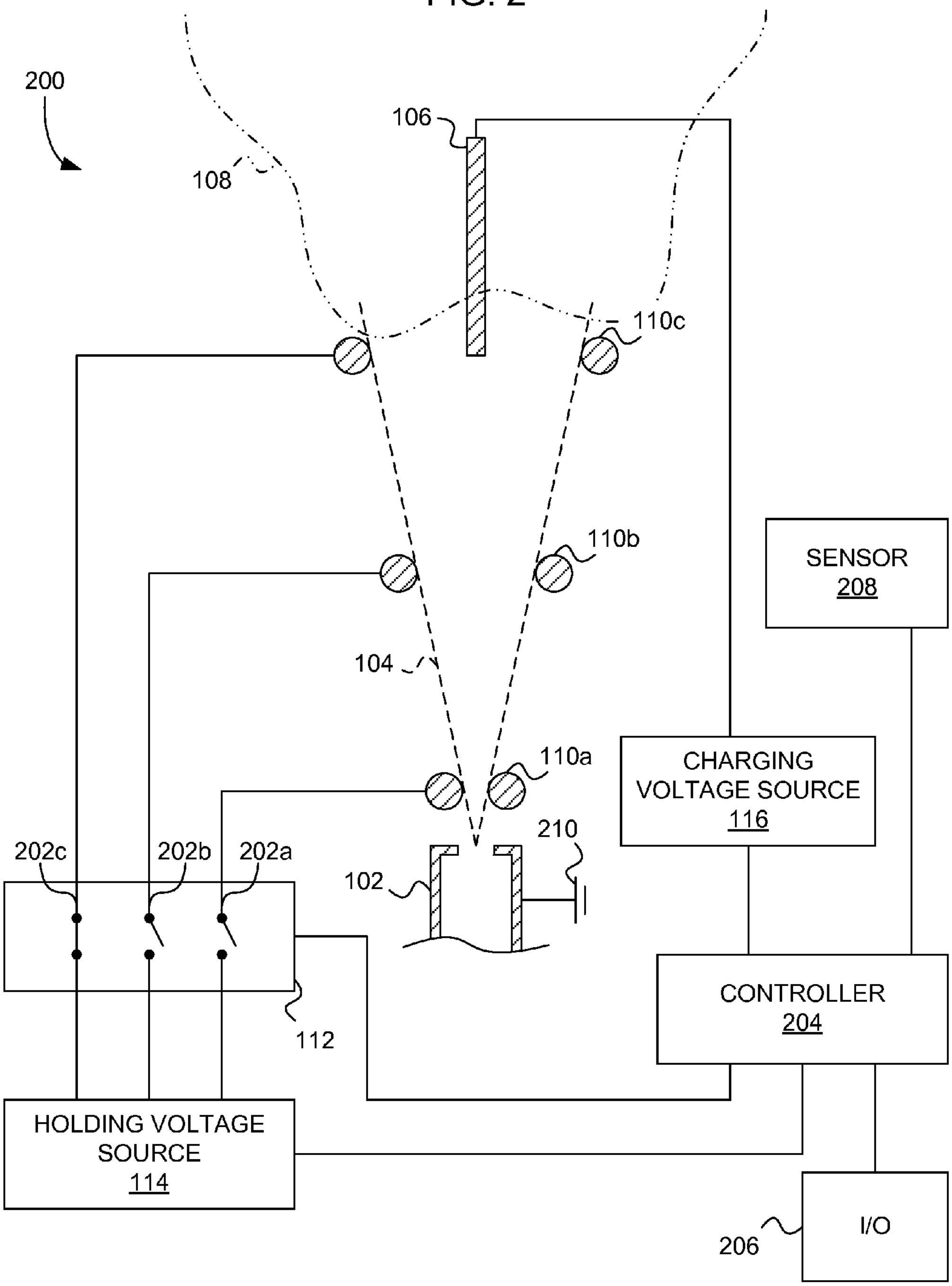

200
106
108
110c
110b
104
110a
210
202c
202b
202a
102
112
SENSOR
208
CHARGING
VOLTAGE SOURCE
116
CONTROLLER
204
HOLDING VOLTAGE
SOURCE
114
I/O
206

FIG. 3

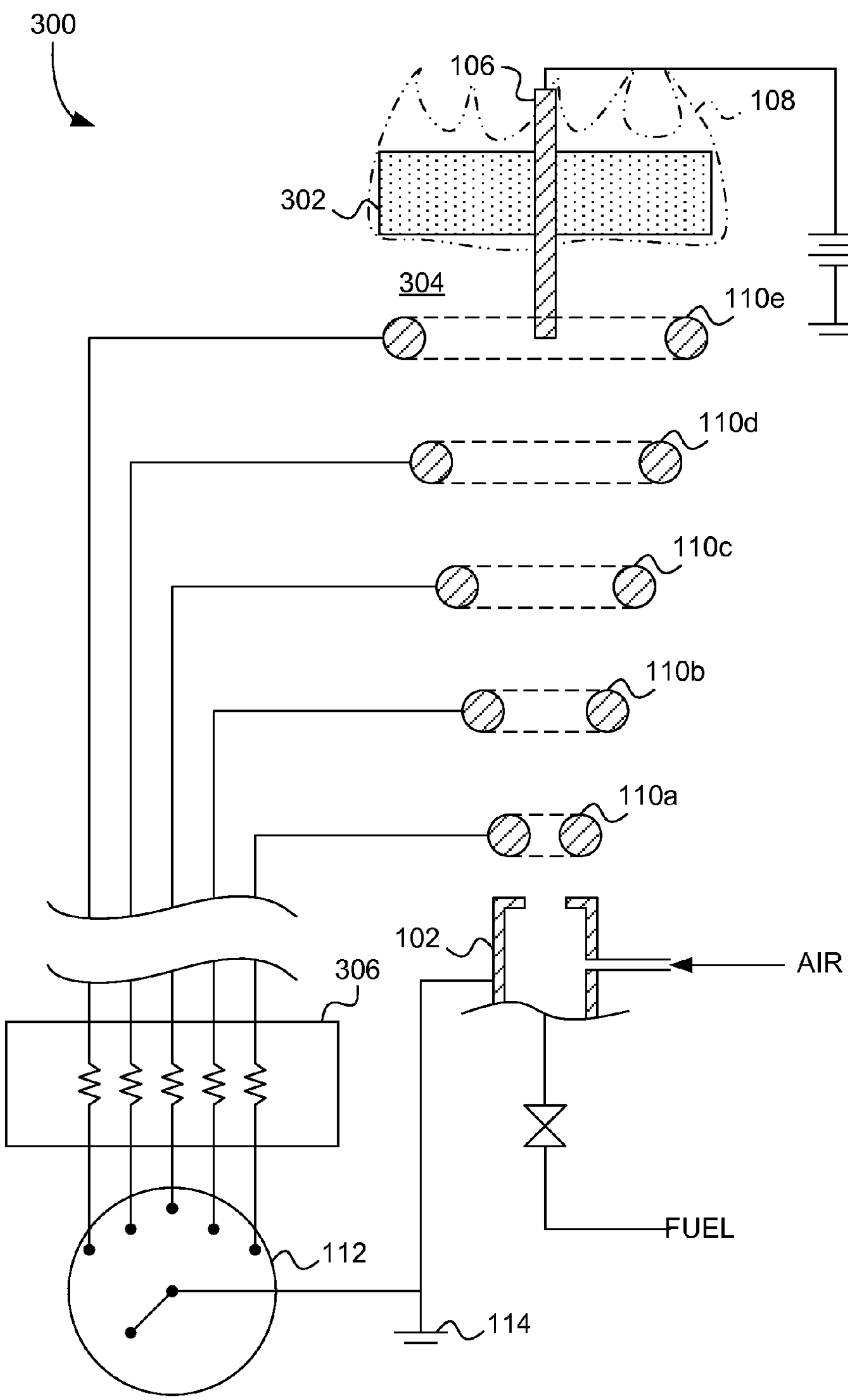
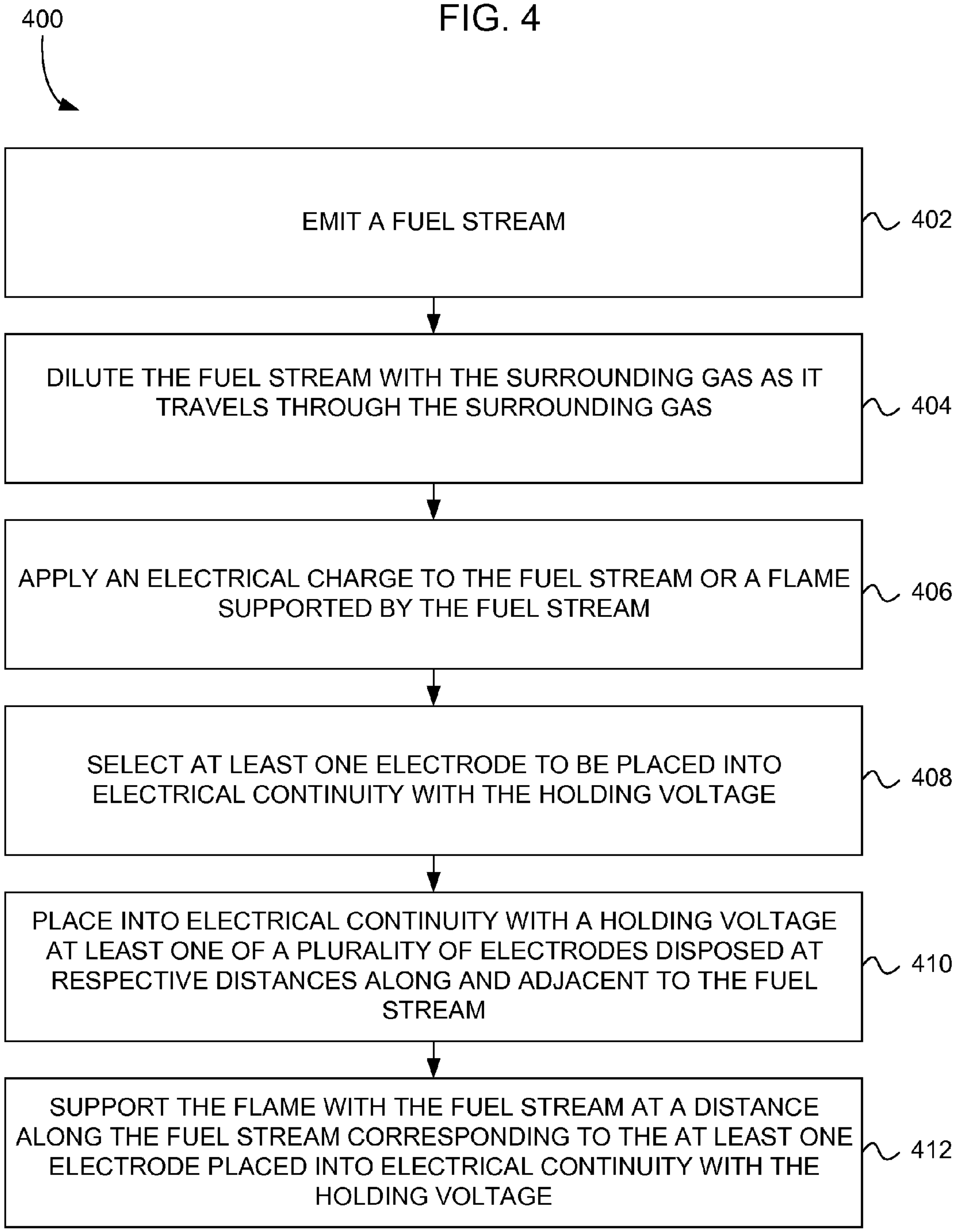

300
106
108
302
116
304
110e
110d
110c
110b
110a
102
AIR
306
FUEL
112
114

FIG. 4


400
EMIT A FUEL STREAM
402
DILUTE THE FUEL STREAM WITH THE SURROUNDING GAS AS IT TRAVELS THROUGH THE SURROUNDING GAS
404
APPLY AN ELECTRICAL CHARGE TO THE FUEL STREAM OR A FLAME SUPPORTED BY THE FUEL STREAM
406
SELECT AT LEAST ONE ELECTRODE TO BE PLACED INTO ELECTRICAL CONTINUITY WITH THE HOLDING VOLTAGE
408
PLACE INTO ELECTRICAL CONTINUITY WITH A HOLDING VOLTAGE AT LEAST ONE OF A PLURALITY OF ELECTRODES DISPOSED AT RESPECTIVE DISTANCES ALONG AND ADJACENT TO THE FUEL STREAM
410
SUPPORT THE FLAME WITH THE FUEL STREAM AT A DISTANCE ALONG THE FUEL STREAM CORRESPONDING TO THE AT LEAST ONE ELECTRODE PLACED INTO ELECTRICAL CONTINUITY WITH THE HOLDING VOLTAGE
412

BURNER WITH FLAME POSITION ELECTRODE ARRAY

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] The present application claims priority benefit from U.S. Provisional Patent Application No. 61/653,722, entitled "LOW NO_X LIFTED FLAME BURNER", filed May 31, 2012, and U.S. Provisional Patent Application No. 61/669,634, entitled "LOW NO_X BURNER AND METHOD OF OPERATING A LOW NO_X BURNER", filed Jul. 9, 2012, which, to the extent not inconsistent with the disclosure herein, are incorporated by reference.

SUMMARY

[0002] According to an embodiment, a burner with flame position electrode array includes a fuel nozzle configured to emit a fuel jet, a flame charger configured to charge the fuel jet or a flame supported by the fuel jet, a plurality of electrodes positioned adjacent to or in a region corresponding to the fuel jet, and a holding voltage switch configured to selectively couple each of the plurality of electrodes to a holding voltage. The charge applied to the fuel jet or flame is selected to form electrical continuity with an electrode coupled to the holding voltage and to cause the flame to occupy a region defined by the electrode coupled to the holding voltage.

[0003] According to another embodiment, a combustion system includes a charging mechanism configured to apply a voltage to a combustion fluid, a plurality of electrodes arranged adjacent to a combustion fluid flow region and configured to selectively hold a flame when the combustion system is below a selected operating temperature, an electrode switch operatively coupled to the plurality of electrodes and configured to selectively make continuity between one or more of the plurality of electrodes and a holding voltage node, and a perforated flame holder arranged to receive a combustion fluid flow after the combustion fluid passes the plurality of electrodes and to hold a flame when the combustion system is at the selected operating temperature.

[0004] According to an embodiment, a method for operating a burner includes emitting a fuel stream, applying an electrical charge to the fuel stream or a flame supported by the fuel stream, placing into electrical continuity with a holding voltage at least one of a plurality of electrodes disposed at respective distances along and adjacent to the fuel stream, and supporting the flame with the fuel stream at a distance along the fuel stream corresponding to the at least one electrode placed into electrical continuity with the holding voltage.

BRIEF DESCRIPTION OF THE DRAWINGS

[0005] FIG. **1** is a diagram of a burner, according to an embodiment.

[0006] FIG. **2** is a diagram of a burner, according to another embodiment.

[0007] FIG. **3** is a diagram of a combustion system, according to an embodiment.

[0008] FIG. **4** is a flow chart illustrative of a method for operating a burner and causing a flame to be in a selected location, according to an embodiment.

DETAILED DESCRIPTION

[0009] In the following detailed description, reference is made to the accompanying drawings, which form a part hereof. In the drawings, similar symbols typically identify similar components, unless context dictates otherwise. The illustrative embodiments described in the detailed description, drawings, and claims are not meant to be limiting. Other embodiments may be utilized, and other changes may be made, without departing from the spirit or scope of the subject matter presented here.

[0010] FIG. **1** is a diagram of a burner **100** including a fuel nozzle **102** configured to emit a fuel jet **104**, according to an embodiment. The burner **100** includes a flame charger **106** configured to charge the fuel jet **104** or a flame **108** supported by the fuel jet **104**. The burner **100** includes a plurality of electrodes **110***a*, **110***b*, **110***c* positioned adjacent to or in a region corresponding to the fuel jet **104**. The burner **100** includes a holding voltage switch **112** configured to selectively couple each of the plurality of electrodes **110***a*, **110***b*, **110***c* to a holding voltage. According to an embodiment, the charge applied to the fuel jet **104** or flame **108** is selected to form electrical continuity with an electrode coupled to the holding voltage and to cause the flame **108** to occupy a region defined by the electrode coupled to the holding voltage.

[0011] According to an embodiment, the plurality of electrodes **110***a*, **110***b*, **110***c* each include a ring electrode arranged at different respective different distances from the fuel nozzle **102** along a direction defined by a fuel jet **104** trajectory. Additionally or alternatively, the plurality of electrodes **110***a*, **110***b*, **110***c* each include a ring electrode disposed along the fuel jet **104** and peripheral to a fuel jet expansion angle.

[0012] Typically, the fuel jet **104** expands at a 15 degree solid angle (7.5 degree half angle) from a centerline of the fuel jet **104** trajectory. This expansion corresponds to dilution of the fuel jet **104** by surrounding gas. In a typical application the fuel jet **104** travels through a furnace volume. In a non-premixed application, the furnace volume may typically include air such as air entrained with the fuel jet **104**. In a premixed application or a non-premixed application, the furnace volume may typically include flue gas including combustion products and about 2 percent to 3 percent oxygen.

[0013] The dilution of the fuel jet **104** causes the burner **100** to output reduced amounts of oxides of nitrogen (NOx) compared to a less diluted fuel jet **104**. However, a more diluted fuel jet **104** may also support a less stable flame **108** than less diluted fuel jet **104**. Flame stability generally improves as a furnace heats up. Accordingly, the plurality of selectively switched electrodes may be useful for maintaining flame stability during start-up and also allow the flame position to be successively moved to more dilute combustion conditions as the furnace volume warms up. In another embodiment, the selectively switched electrodes can be used to establish an optimized flame position as a function of fuel flow rate, for example.

[0014] According to an embodiment, diameters of the respective ring electrodes are selected to cause the flame **108** supported by the fuel jet **104** to detach from a ring electrode not coupled to the holding voltage. Additionally, the distances of the respective ring electrodes along a fuel jet **104** trajectory are selected to cause the flame **108** supported by the fuel jet **104** to detach from a ring electrode not coupled to the holding voltage.

[0015] According to an embodiment, the fuel nozzle **102** includes a pre-mix nozzle and the fuel jet **104** includes a mixed fuel and air jet. Additionally or alternatively, the fuel nozzle **102** can include a partial pre-mix nozzle and the fuel jet **104** includes a partially premixed fuel and air jet. According to an embodiment, the fuel jet **104** includes a hydrocarbon gas, for example, natural gas and/or propane. According to another embodiment, the fuel jet **104** includes a hydrocarbon liquid. The hydrocarbon liquid can include atomized fuel oil.

[0016] According to another embodiment, the fuel jet **104** comprises process gas including carbon monoxide and hydrogen.

[0017] The burner **100** includes a holding voltage source **114** operatively coupled to the holding voltage switch **112**. The holding voltage source **114** is configured to output a holding voltage opposite in polarity from the charge applied to the fuel jet **104** or flame **108**. According to an embodiment, the flame charger **106** is configured to output a time-varying charge polarity to the fuel jet **104** or the flame **108** supported by the fuel jet **104**. Additionally, the holding voltage source **114** is configured to output a time-varying holding voltage substantially opposite in polarity from the time-varying charge polarity output to the fuel jet **104** or the flame **108** supported by the fuel jet **104**, according to an embodiment.

[0018] The burner **100** includes a charging voltage source **116** configured to output a flame charging voltage to the flame charger **106**, according to an embodiment. The charging voltage source **116** and the holding voltage source **114** are synchronized to output periodically varying and opposite voltage polarities. The charging voltage source **116** and the holding voltage source **114** are formed as portions of a single power supply.

[0019] According to an embodiment, the flame charger **106** is configured to output a constant charge polarity to the fuel jet **104** or the flame **108** supported by the fuel jet **104**. Additionally, the holding voltage source **114** is configured to output a substantially constant holding voltage opposite in polarity from the charge polarity output to the fuel jet **104** or the flame **108** supported by the fuel jet **104**.

[0020] According to an embodiment, the holding voltage includes voltage ground.

[0021] The burner **100** includes a charging voltage source **116** configured to output a flame charging voltage to the flame charger **106**, according to an embodiment. The flame charger **106** comprises a corona electrode configured to emit ions having a polarity the same as the voltage output by the charging voltage source **116**.

[0022] According to an embodiment, the flame charger **106** is configured to charge the fuel stream and/or charge the flame **108**. The flame charger **106** includes an ionizer configured to output charged particles into combustion air and/or configured to output charged particles into fuel.

[0023] The charged particles can include fuel or air molecules, for example. In some embodiments, a flue gas may be charged and the charge transferred to the fuel jet **104** or the flame **108**. The charged particles in the flue gas may include positive hydronium ions or negative hydroxide ions, for example. In some embodiments, negative particles may include electrons.

[0024] According to an embodiment, the flame charger **106** includes an ionizer and a dielectric charge delivery tube. The ionizer is located outside a combustion volume surrounding the flame **108**. The dielectric charge delivery tube is configured to deliver charged particles from the ionizer to a region near or in the flame **108**. Additionally or alternatively, the dielectric charge delivery tube is configured to deliver charged particles from the ionizer to a region near or in the fuel jet **104**.

[0025] The burner **100** includes an interface **118** configured to control the holding voltage switch **112**, according to an embodiment. The interface **118** includes a human interface for manual control of the holding voltage switch **112**. Additionally or alternatively, the interface **118** includes a data interface operatively coupled to an electronic controller (not shown) adapted for automatic control of the holding voltage switch **112**.

[0026] FIG. **2** is a diagram of a burner **200**, according to another embodiment. The flame charger **106** includes a charge rod suspended in the flame **108**. The holding voltage switch **112** includes a plurality of switch elements **202*a***, **202*b***, **202*c*** respectively operatively coupled to the plurality of electrodes **110*a***, **110*b***, **110*c***.

[0027] As illustrated in FIG. **2** switch elements **202*a*** and **202*b***, respectively coupled to electrodes **110*a***, **110*b*** can be opened, causing the electrodes **110*a***, **110*b*** to float to a local voltage. Causing the electrodes **110*a***, **110*b*** to electrically float causes zero net current between the fuel jet **104** and the electrodes **110*a***, **110*b***. Zero net current causes the flame **108** not to attach to the electrically floating electrodes **110*a***, **110*b***. Another switch element **202*c*** can make continuity between a holding voltage source **114** and an electrode **110*c***. Electrical continuity between charges (as voltage) applied to the flame **108** and the holding voltage causes the flame **108** to be held by the electrode **110*c***.

[0028] According to embodiments, the switch elements include magnetically actuated switches, mechanically actuated switches, include reed switches, and/or insulated gate bipolar transistors.

[0029] According to an embodiment, the holding voltage switch **112** is configured for automatic control. The burner **200** includes an electronic controller **204** operatively coupled to the holding voltage switch **112**. A data communication interface **206** is operatively coupled to the electronic controller **204**. The data communication interface **206** is coupled to receive master control signals from a remote controller (not shown), according to an embodiment.

[0030] According to an embodiment, a sensor **208** is operatively coupled to the electronic controller **204** and configured to sense at least one parameter corresponding to the flame **108**. The sensor **208** includes a temperature sensor. The electronic controller **204** is configured to automatically select a switch element for making continuity between a corresponding electrode and a holding voltage source **114** responsive to data or a signal from the sensor **208**

[0031] The fuel nozzle **210** can be operatively coupled to a voltage ground **210**. In some embodiments, the holding voltage source **114** can consist essentially of the voltage ground **210**. For embodiments where the holding voltage source **114** is embodied as a voltage ground, the control interface to the controller **204** can be omitted. Optionally, the control interface between the controller **204** and the charging voltage source **116** can be omitted. Where the control interface between the controller **204** and the charging voltage source **116** is present, the control functionality can be limited to on or off, according to some embodiments. In other embodiments, the controller **204** and the charging voltage source **116** can be arranged to cooperate to output a selected charge density, charge polarity, and/or charge waveform.

[0032] FIG. **3** is a diagram of a combustion system **300**, including a charging mechanism **106** configured to apply a voltage to a combustion fluid, according to an embodiment. The combustion system **300** includes a plurality of electrodes

110*a-e* arranged adjacent to a combustion fluid flow region and configured to selectively hold a flame **108** when the combustion system **300** is below a selected operating temperature. The combustion system **300** includes a holding voltage switch **112** operatively coupled to the plurality of electrodes **110***a-e* and configured to selectively make continuity between one or more of the plurality of electrodes **110***a-e* and a holding voltage node **114**. The combustion system **300** includes a perforated flame holder **302** arranged to receive a combustion fluid flow after the combustion fluid passes the plurality of electrodes **110***a-e* and to hold a flame **108** when the combustion system **300** is at the selected operating temperature.

[0033] According to an embodiment, the combustion fluid includes the flame **108**, a fuel stream, combustion air, and/or flue gas.

[0034] According to an embodiment, the combustion system **300** is below the selected operating temperature when a combustion volume **304** surrounding the plurality of electrodes **110***a-e* and the perforated flame holder **302** is below the selected operating temperature.

[0035] The combustion system **300** is at the selected operating temperature when a combustion volume **304** surrounding the plurality of electrodes **110***a-e* and the perforated flame holder **302** is at or above a minimum temperature. According to an embodiment, the minimum temperature is about 1000 degrees Fahrenheit or higher. According to another embodiment, the minimum temperature is about 1200 degrees Fahrenheit or higher.

[0036] According to an embodiment, the perforated flame holder **302** is configured to support a flame **108** that outputs oxides of nitrogen (NOx) at or below about 15 parts per million at 2% to 3% residual oxygen concentration in a flue gas. According to another embodiment, the perforated flame holder **302** is configured to support a flame **108** that outputs oxides of nitrogen (NOx) at or below about 8 parts per million at 2% to 3% residual oxygen concentration in a flue gas. According to another embodiment, the perforated flame holder **302** is configured to support a flame **108** that outputs oxides of nitrogen (NOx) at or below about 5 parts per million at 2% to 3% residual oxygen concentration in a flue gas. According to another embodiment, the perforated flame holder **302** is configured to support a flame **108** that outputs oxides of nitrogen (NOx) at or below about 2 parts per million at 2% to 3% residual oxygen concentration in a flue gas. According to another embodiment, the perforated flame holder **302** is configured to support a flame **108** that outputs oxides of nitrogen (NOx) at or below 0.5 parts per million at 2% to 3% residual oxygen concentration in a flue gas.

[0037] The combustion system **300** includes a charging voltage source **116** configured to apply the voltage to the charging mechanism **106**. According to an embodiment, the charging voltage source **116** is configured to output about 15 kilovolts to the charging mechanism **106**.

[0038] According to an embodiment, the holding voltage node **114** comprises a voltage ground.

[0039] According to an embodiment, the holding voltage switch **112** includes a rotary selector switch.

[0040] The combustion system **300** includes a resistor **306** operatively coupled between the plurality of electrodes **110***a-e* and the holding voltage switch **112**. The resistor **306** includes a plurality of resistors, each of the plurality of resistors coupled between a respective electrode and a node on the holding voltage switch **112**. According to an embodiment, the resistor **306** is selected to reduce electrical arcing between each of the plurality of electrodes **110***a-e* and the combustion fluid. The resistor **306** includes a plurality of resistors each having a resistance between about 4 and 10 megaohms. According to another embodiment, the resistor **306** includes a plurality of resistors each having a resistance of between 6 and 8 megaohms. The resistor **306** can alternatively be inserted between the holding voltage switch **112** and the holding voltage node **114**.

[0041] FIG. **4** is a flow chart illustrative of a method **400** for operating a burner and causing a flame to be in a selected location, according to an embodiment. The method **400** for operating a burner begins with step **402**, wherein a fuel stream is emitted. Step **402** includes emitting a hydrocarbon gas and/or a hydrocarbon gas premixed with air. According to another embodiment step **402** emitting a fuel stream includes emitting a hydrocarbon liquid and/or emitting a hydrocarbon liquid premixed with air. Additionally, emitting a hydrocarbon liquid can include atomizing the hydrocarbon liquid. Step **402** can include emitting a premixed air and fuel stream, emitting pure fuel and/or emitting the fuel stream through a surrounding gas. Proceeding to step **404**, the fuel stream is diluted with the surrounding gas as it travels through the surrounding gas, according to an embodiment. In step **404** the fuel stream becomes progressively more dilute as it travels through the surrounding gas. According to an embodiment, the surrounding gas can include air, air entrained with the fuel stream, and/or flue gas.

[0042] In step **406** an electrical charge is applied to the fuel stream or a flame supported by the fuel stream, according to an embodiment. Step **406** can include applying a voltage to a charge electrode that contacts the flame. Step **406** also can include applying a charge voltage to a corona electrode to emit charged particles into the fuel stream.

[0043] According to an embodiment, step **406** can include operating an ionizer to place charged particles into an air stream entrained with the fuel stream and/or operating the ionizer to place charged particles into air or a flue gas surrounding the fuel stream.

[0044] Step **406** can include operating a charge voltage source to generate a high voltage corresponding to a charge density applied to the fuel stream or flame supported by the fuel stream. According to an embodiment, the high voltage is greater than 1000 volts magnitude. According to another embodiment, the high voltage is about 15,000 volts magnitude.

[0045] According to an embodiment, step **406** can include placing a positive polarity voltage, placing a negative polarity voltage, and/or placing an alternating polarity voltage on a charge electrode or ionizer operatively coupled to the fuel stream or flame.

[0046] Proceeding to step **408**, at least one electrode is selected to be placed into electrical continuity with the holding voltage, according to an embodiment. Step **408** includes selecting a distance along the fuel stream to support the flame and/or selecting a location along the fuel stream to support the flame to maintain flame stability. The at least one electrode placed into electrical continuity with the holding voltage corresponds to at least one fuel stream dilution corresponding to the selected location. Additionally, step **408** includes selecting a location along the fuel stream to support the flame to minimize an evolution of an oxide of nitrogen (NOx) from the flame.

[0047] According to an embodiment, step **408** may additionally or alternatively include selecting a distance along the fuel stream corresponding to a location where it is advantageous to concentrate or minimize concentration of a charged reactant. By balancing charge-responsive behavior (relative attraction or repulsion to or from an electrical polarity) against molecular weight or molecular diameter-responsive behavior (flow velocity at a location), a selected charged moiety can be caused to have a concentration gradient with respect to the electrode to which the voltage is applied.

[0048] According to an embodiment, step **408** includes selecting a sequence of locations through which the flame is to be moved. For example, in step **408** a parameter corresponding to the flame is measured, an algorithm is executed, a database is addressed, and a look-up table (LUT) is accessed to select the at least one electrode. In step **408** a sensor is operated to measure a combustion volume parameter and the measured combustion volume parameter is used to select the at least one electrode. Additionally, in step **408** an action is determined to move the flame to a perforated flame holder and a sequence of electrodes is selected to move the flame to the perforated flame holder.

[0049] Proceeding to step **410**, at least one of a plurality of electrodes disposed at respective distances along and adjacent to the fuel stream is placed into electrical continuity with a holding voltage, according to an embodiment. Step **410** includes placing one of the plurality of electrodes into electrical continuity with the holding voltage. Additionally or alternatively, step **410** includes placing two of the plurality of electrodes into electrical continuity with the holding voltage.

[0050] In instances where more than one of the plurality of electrodes is placed into electrical continuity with the holding voltage, the flame will generally attach to one of the electrodes placed into electrical continuity with the holding voltage. Which one of the electrodes will act as the flame attachment depends on the equilibrium position of the flame relative to the plurality of electrodes. For an instance where the equilibrium flame location is proximal to the fuel emission point (e.g., a fuel nozzle) compared to the plurality of electrodes, the flame will attach to the most proximal of the electrodes placed into electrical continuity with the holding voltage. For an instance where the equilibrium flame location is distal from the fuel emission point compared to the plurality of electrodes, the flame will attach to the most distal of the electrodes placed into electrical continuity with the holding voltage. In an embodiment, one electrode may be selected for being placed into electrical continuity with the holding voltage to establish a known flame location. Two electrodes may be momentarily placed into electrical continuity with the holding voltage to move the flame between the electrodes, followed by breaking electrical continuity between the holding voltage and the electrode from which the flame is moved.

[0051] According to an embodiment, step **410** includes placing at least one of the plurality of electrodes into electrical continuity with voltage ground. Additionally or alternatively, step **410** can include placing at least one of the plurality of electrodes into electrical continuity with a voltage opposite in polarity from the electrical charge applied to the fuel stream or the flame supported by the fuel stream.

[0052] According to an embodiment, in step **412** the flame is supported by the fuel stream at a distance along the fuel stream corresponding to the at least one electrode placed into electrical continuity with the holding voltage.

[0053] While various aspects and embodiments have been disclosed herein, other aspects and embodiments are contemplated. The various aspects and embodiments disclosed herein are for purposes of illustration and are not intended to be limiting, with the true scope and spirit being indicated by the following claims.

1. A burner, comprising:
a fuel nozzle configured to emit a fuel jet;
a flame charger configured to charge the fuel jet or a flame supported by the fuel jet;
a plurality of electrodes positioned adjacent to or in a region corresponding to the fuel jet; and
a holding voltage switch configured to selectively couple each of the plurality of electrodes to a holding voltage;
wherein the charge applied to the fuel jet or flame is selected to form electrical continuity with an electrode coupled to the holding voltage and to cause the flame to occupy a region defined by the electrode coupled to the holding voltage.

2. The burner of claim **1**, wherein the plurality of electrodes each include a ring electrode arranged at different respective different distances from the fuel nozzle along a direction defined by a fuel jet trajectory.

3. The burner of claim **1**, wherein the plurality of electrodes each include a ring electrode disposed along the fuel jet and peripheral to a fuel jet expansion angle.

4. The burner of claim **3**, wherein diameters of the respective ring electrodes are selected to cause the flame supported by the fuel jet to detach from a ring electrode not coupled to the holding voltage.

5. The burner of claim **3**, wherein the distances of the respective ring electrodes along a fuel jet trajectory are selected to cause the flame supported by the fuel jet to detach from a ring electrode not coupled to the holding voltage.

6.-**7**. (canceled)

8. The burner of claim **1**, further comprising: a holding voltage source operatively coupled to the holding voltage switch.

9. The burner of claim **8**, wherein the holding voltage source is configured to output a holding voltage opposite in polarity from the charge applied to the fuel jet or flame.

10. The burner of claim **8**, wherein the flame charger is configured to output a time-varying charge polarity to the fuel jet or the flame supported by the fuel jet; and
wherein the holding voltage source is configured to output a time-varying holding voltage substantially opposite in polarity from the time-varying charge polarity output to the fuel jet or the flame supported by the fuel jet.

11. The burner of claim **8**, further comprising:
a charging voltage source configured to output a flame charging voltage to the flame charger.

12. The burner of claim **11**, wherein the charging voltage source and the holding voltage source are synchronized to output periodically varying and opposite voltage polarities.

13. The burner of claim **11**, wherein the charging voltage source and the holding voltage source are formed as portions of a single power supply.

14. The burner of claim **8**, wherein the flame charger is configured to output a constant charge polarity to the fuel jet or the flame supported by the fuel jet; and
wherein the holding voltage source is configured to output a substantially constant holding voltage opposite in polarity from the charge polarity output to the fuel jet or the flame supported by the fuel jet.

15. The burner of claim **1**, wherein the holding voltage includes voltage ground.

16.-**20**. (canceled)

21. The burner of claim **1**, wherein the flame charger includes an ionizer configured to output charged particles.

22.-**23**. (canceled)

24. The burner of claim **1**, further comprising an interface configured to control the holding voltage switch.

25. The burner of claim **24**, wherein the interface includes a human interface for manual control of the holding voltage switch.

26. The burner of claim **24**, wherein the interface includes a data interface operatively coupled to an electronic controller adapted for automatic control of the holding voltage switch

27. The burner of claim **1**, wherein the flame charger includes a charge rod suspended in the flame.

28. The burner of claim **1**, wherein the holding voltage switch includes a plurality of switch elements respectively operatively coupled to the plurality of electrodes.

29. The burner of claim **1**, wherein the electrode switch is configured for automatic control.

30. The burner of claim **1**, further comprising:

an electronic controller operatively coupled to the electrode switch.

31. The burner of claim **30**, further comprising:

a sensor operatively coupled to the electronic controller and configured to sense at least parameter corresponding to the flame.

32. The burner of claim **31**, wherein the sensor includes a temperature sensor.

33. The burner of claim **31**, wherein the electronic controller is configured to automatically select a switch element for making continuity between a corresponding electrode and a holding voltage source responsive to data or a signal from the sensor.

34. A combustion system, comprising:

a charging mechanism configured to apply a voltage to a combustion fluid;

a plurality of electrodes arranged adjacent to a combustion fluid flow region and configured to selectively hold a flame when the combustion system is below a selected operating temperature;

an electrode switch operatively coupled to the plurality of electrodes and configured to selectively make continuity between one or more of the plurality of electrodes and a holding voltage node; and

a perforated flame holder arranged to receive a combustion fluid flow after the combustion fluid passes the plurality of electrodes and to hold a flame when the combustion system is at the selected operating temperature.

35.-**48**. (canceled)

49. The combustion system of claim **34**, further comprising a resistor operatively coupled between the plurality of electrodes and the electrode switch.

50. The combustion system of claim **49**, wherein the resistor includes a plurality of resistors, each of the plurality of resistors coupled between a respective electrode and a node on the electrode switch.

51. The combustion system of claim **49**, wherein the resistor is selected to reduce electrical arcing between each of the plurality of electrodes and the combustion fluid.

52. The combustion system of claim **49**, wherein the resistor includes a plurality of resistors each having a resistance between about 4 and 10 megaohms.

53. The combustion system of claim **52**, wherein the resistor includes a plurality of resistors each having a resistance of between 6 and 8 megaohms.

54. A method for operating a burner, comprising:

emitting a fuel stream;

applying an electrical charge to the fuel stream or a flame supported by the fuel stream;

placing into electrical continuity with a holding voltage at least one of a plurality of electrodes disposed at respective distances along and adjacent to the fuel stream; and

supporting the flame with the fuel stream at a distance along the fuel stream corresponding to the at least one electrode placed into electrical continuity with the holding voltage.

55. The method for operating a burner of claim **54**, wherein emitting a fuel stream includes emitting a premixed air and fuel stream.

56. The method for operating a burner of claim **54**, wherein emitting a fuel stream includes emitting pure fuel.

57. The method for operating a burner of claim **54**, wherein emitting the fuel stream includes emitting the fuel stream through a surrounding gas; and

further comprising:

diluting the fuel stream with the surrounding gas as it travels through the surrounding gas.

58. The method for operating a burner of claim **57**, wherein the fuel stream becomes progressively more dilute as it travels through the surrounding gas.

59. The method for operating a burner of claim **58**, wherein the at least one electrode placed into electrical continuity with the holding voltage corresponds to at least one fuel stream dilution.

60. The method for operating a burner of claim **57**, wherein the surrounding gas includes air.

61. The method for operating a burner of claim **60**, wherein the surrounding gas includes air entrained with the fuel stream.

62. The method for operating a burner of claim **57**, wherein the surrounding gas includes flue gas.

63. The method for operating a burner of claim **54**, wherein applying an electrical charge to the fuel stream or a flame supported by the fuel stream includes applying a voltage to a charge electrode that contacts the flame.

64. The method for operating a burner of claim **54**, wherein applying an electrical charge to the fuel stream or a flame supported by the fuel stream includes applying a charge voltage to a corona electrode to emit charged particles.

65.-**69**. (canceled)

70. The method for operating a burner of claim **54**, wherein applying an electrical charge to the fuel stream or a flame supported by the fuel stream includes placing a positive polarity voltage on a charge electrode or ionizer operatively coupled to the fuel stream or flame.

71. The method for operating a burner of claim **54**, wherein applying an electrical charge to the fuel stream or a flame supported by the fuel stream includes placing a negative polarity voltage on a charge electrode or ionizer operatively coupled to the fuel stream or flame.

72. The method for operating a burner of claim **54**, wherein applying an electrical charge to the fuel stream or a flame supported by the fuel stream includes placing an alternating polarity voltage on a charge electrode or ionizer operatively coupled to the fuel stream or flame.

73. The method for operating a burner of claim **54**, further comprising:

selecting the at least one electrode to be placed into electrical continuity with the holding voltage.

74. The method for operating a burner of claim **73**, wherein selecting the at least one electrode includes selecting a distance along the fuel stream to support the flame.

75. The method for operating a burner of claim **73**, wherein selecting the at least one electrode includes selecting a location along the fuel stream to support the flame to maintain flame stability.

76. The method for operating a burner of claim **73**, wherein selecting the at least one electrode includes selecting a location along the fuel stream to support the flame to minimize an evolution of an oxide of nitrogen (NOx) from the flame.

77. The method for operating a burner of claim **73**, wherein selecting the at least one electrode includes selecting a sequence of locations through which the flame is to be moved.

78.-**80**. (canceled)

81. The method for operating a burner of claim **73**, wherein selecting the at least one electrode further comprises:

operating a sensor to measure a combustion volume parameter; and

using the measured combustion volume parameter to select the at least one electrode.

82. The method for operating a burner of claim **73**, wherein selecting the at least one electrode further comprises:

determining an action to move the flame to a perforated flame holder; and

selecting a sequence of electrodes to move the flame to the perforated flame holder.

83.-**84**. (canceled)

85. The method for operating a burner of claim **54**, wherein placing at least one of the plurality of electrodes into electrical continuity with the holding voltage includes placing at least one of the plurality of electrodes into electrical continuity with voltage ground

86. The method for operating a burner of claim **54**, wherein placing at least one of the plurality of electrodes into electrical continuity with the holding voltage includes placing at least one of the plurality of electrodes into electrical continuity with a voltage opposite in polarity from the electrical charge applied to the fuel stream or the flame supported by the fuel stream.

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