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Schlosser et al.

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(54) **CURVILINEAR BURNER TUBE**

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(51) **Int. Cl.**^{7} **F24C 3/08**; F23D 14/62
(52) **U.S. Cl.** .... **431/354**; 126/41 R; 126/39 R
(58) **Field of Search** .... 431/354; 126/41 R, 126/39 R; 239/553, 566, 565

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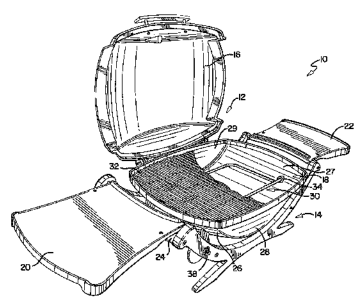
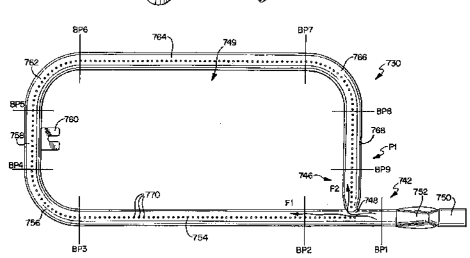
(57) **ABSTRACT**

The present invention provides a burner tube. The burner tube has a proximal segment, a distal segment, a terminal end, and a plurality of fuel outlet ports. The proximal segment has a union region and is adapted to be connected to a fuel source. The terminal end of the burner tube is connected to the union region such that the terminal end is in fluid communication with the union region. The connection between the terminal end and union region forms a continuous burner tube, or a burner loop for the flow of fuel. An initial flow of fuel diverges in the union region into a first portion and a second portion. The first portion flows through the union region and downstream through the distal segment. The second portion of fuel from the fuel source flows through the union region and downstream through the terminal end.

20 Claims, 7 Drawing Sheets





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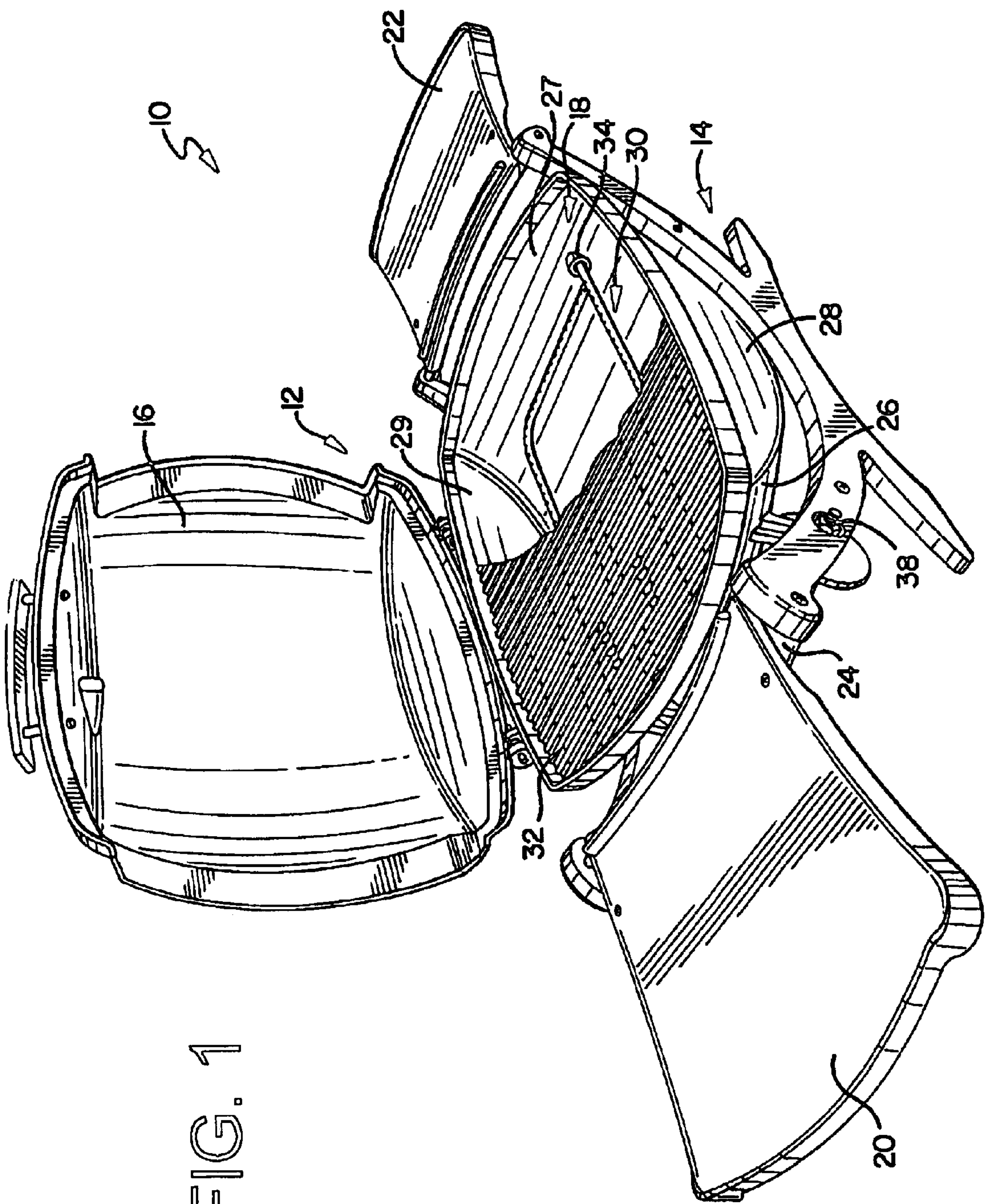


FIG. 1

FIG. 2

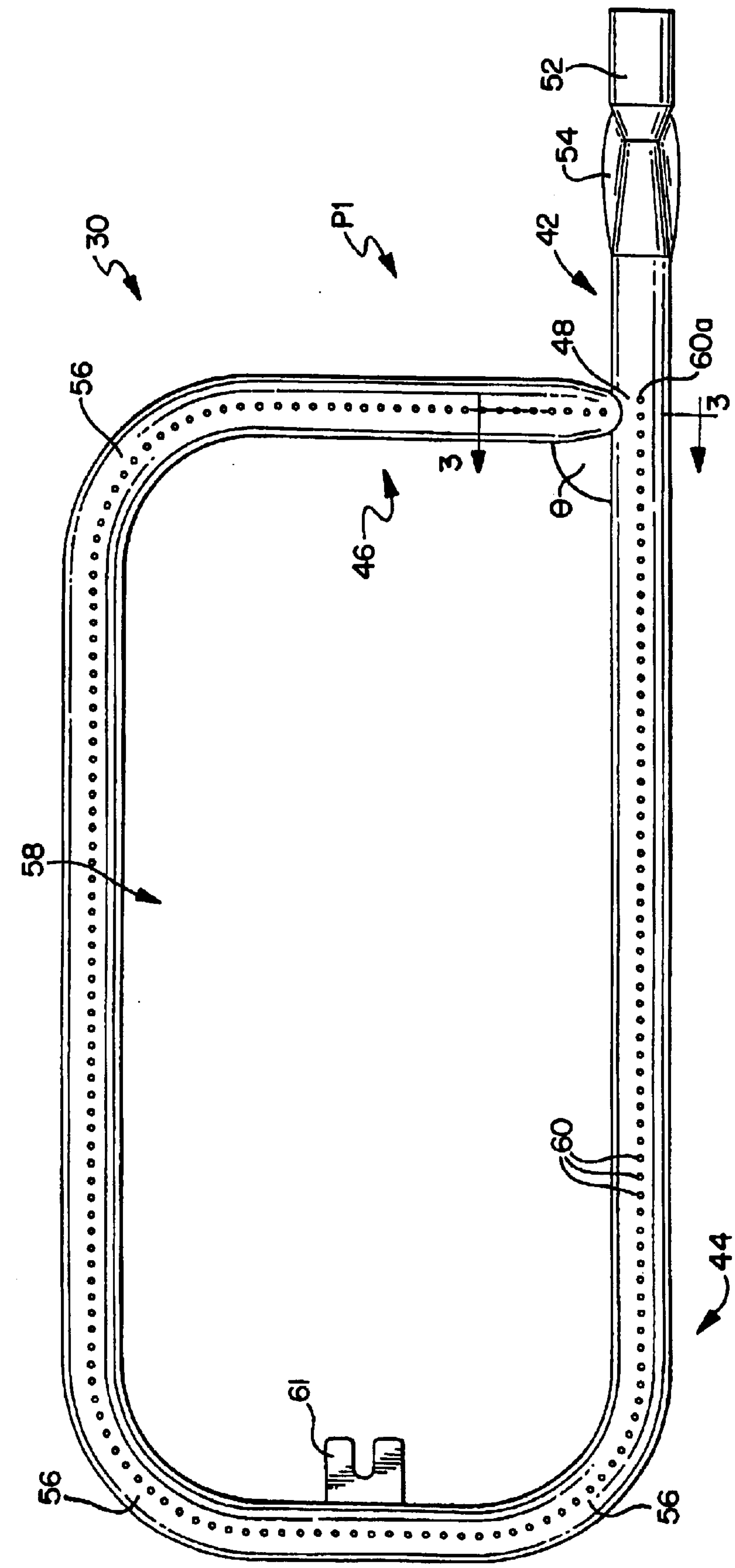


FIG. 3

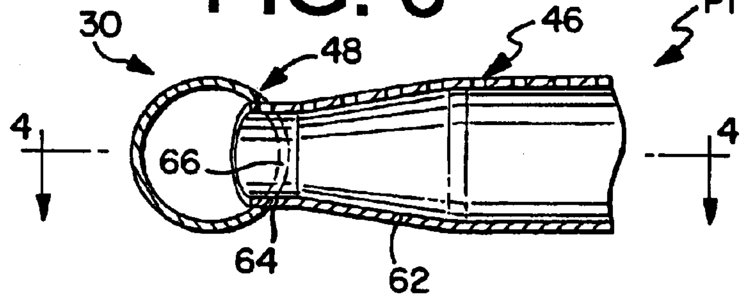


FIG. 4

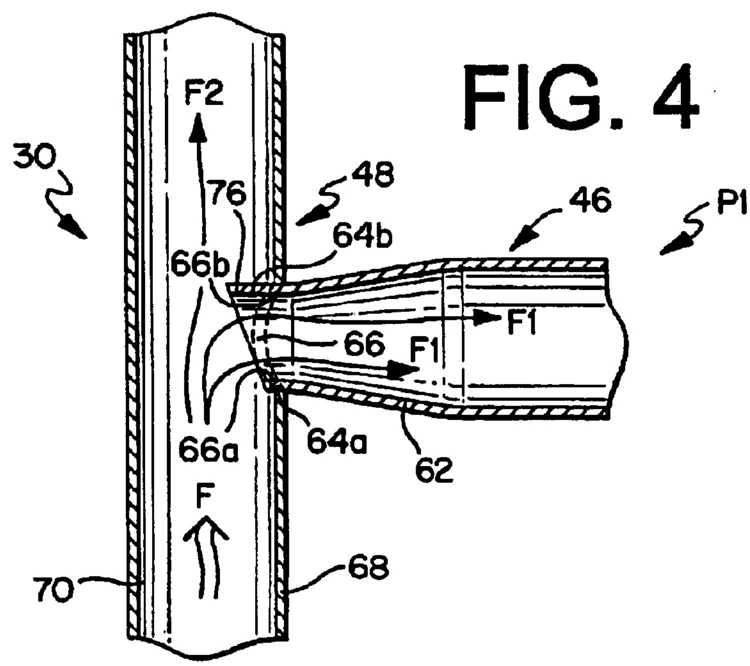
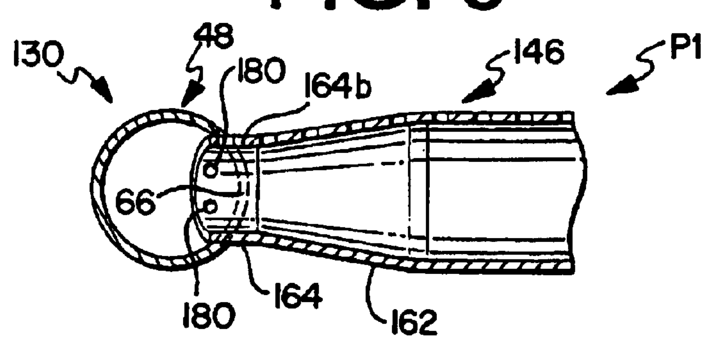


FIG. 5



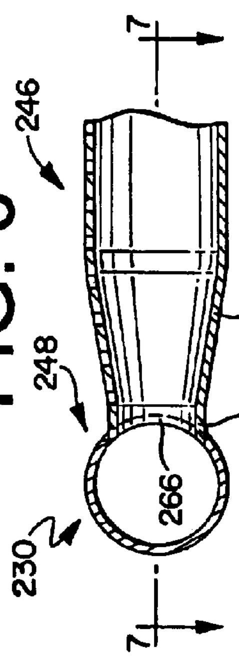


FIG. 6

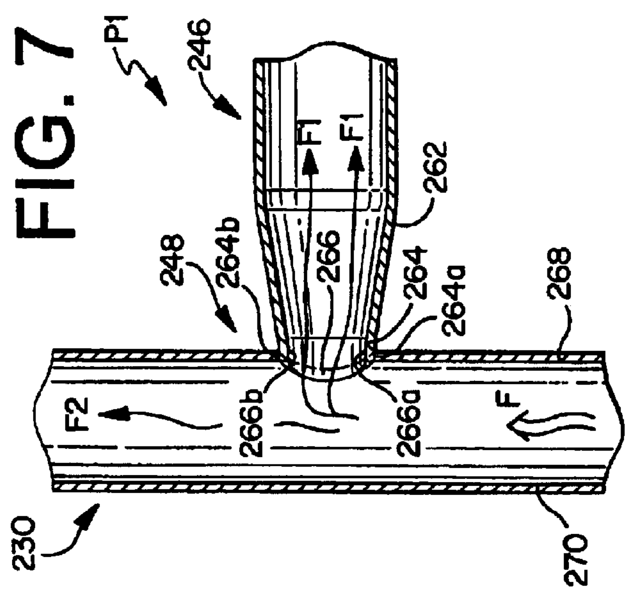


FIG. 7

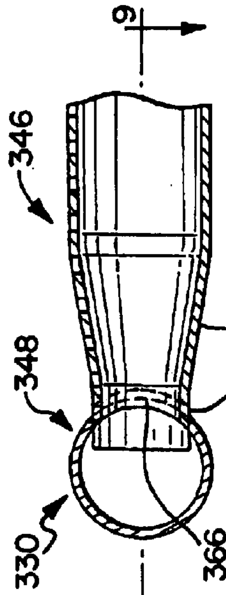


FIG. 8

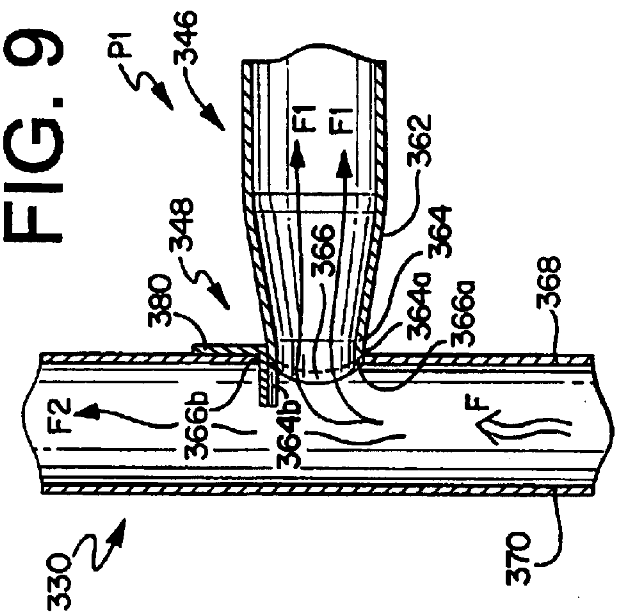


FIG. 9

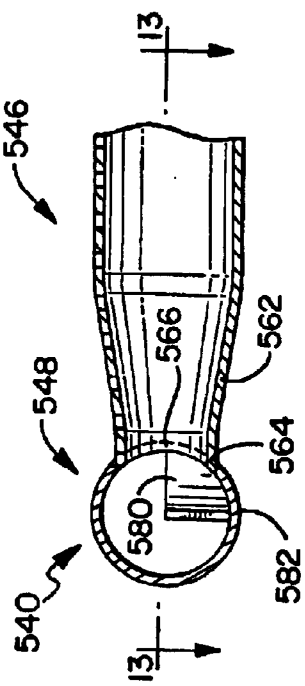


FIG. 12

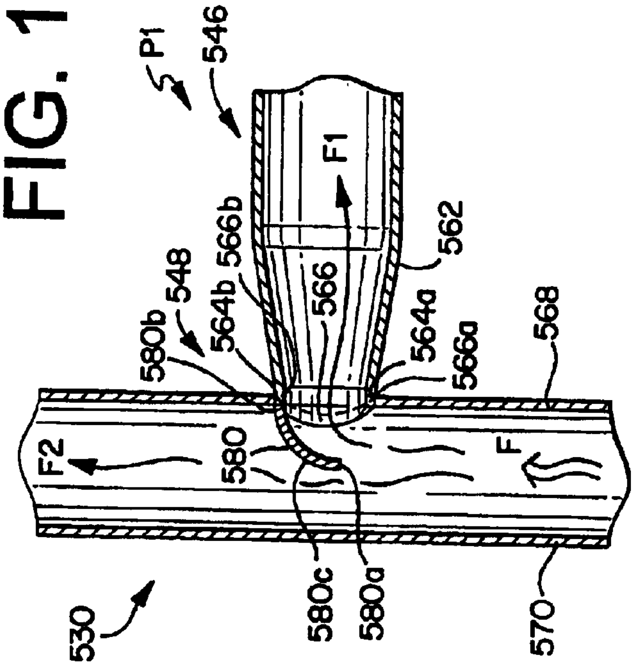


FIG. 13

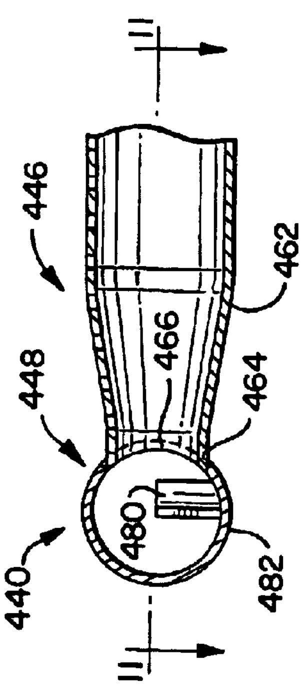


FIG. 10

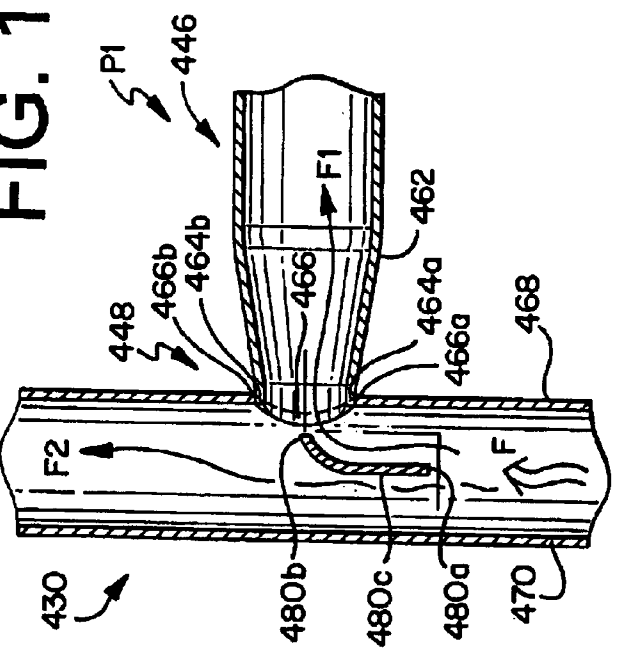
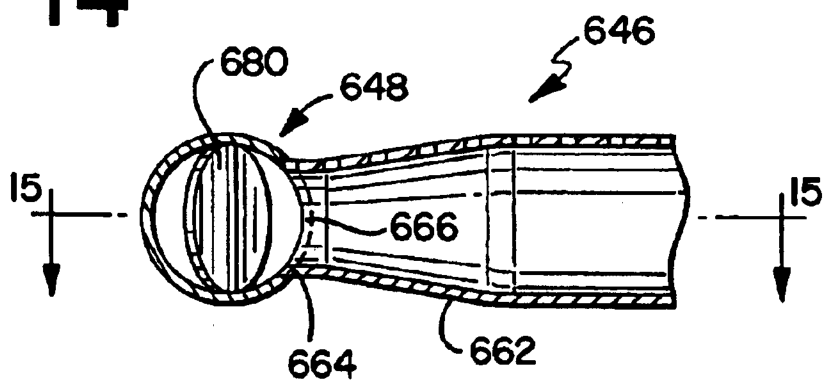


FIG. 11

FIG. 14


646
680
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666
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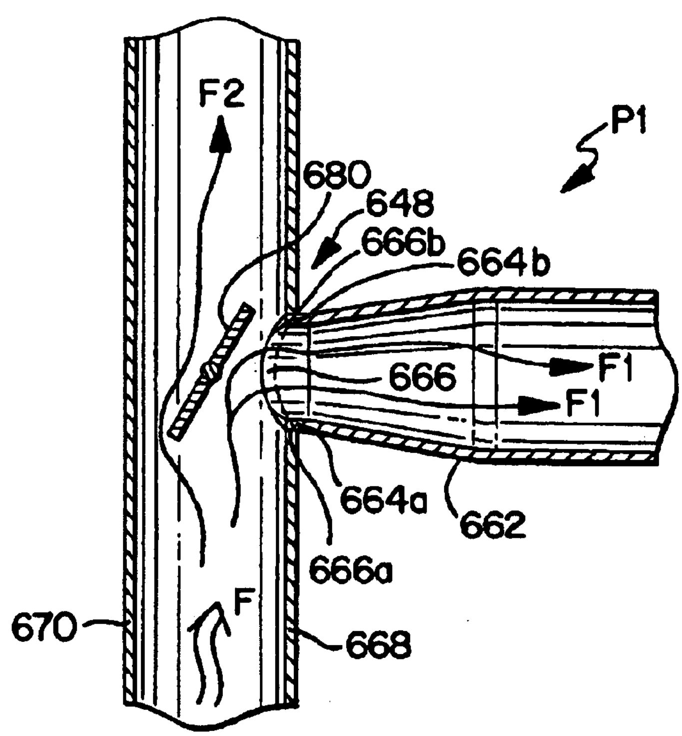
FIG. 15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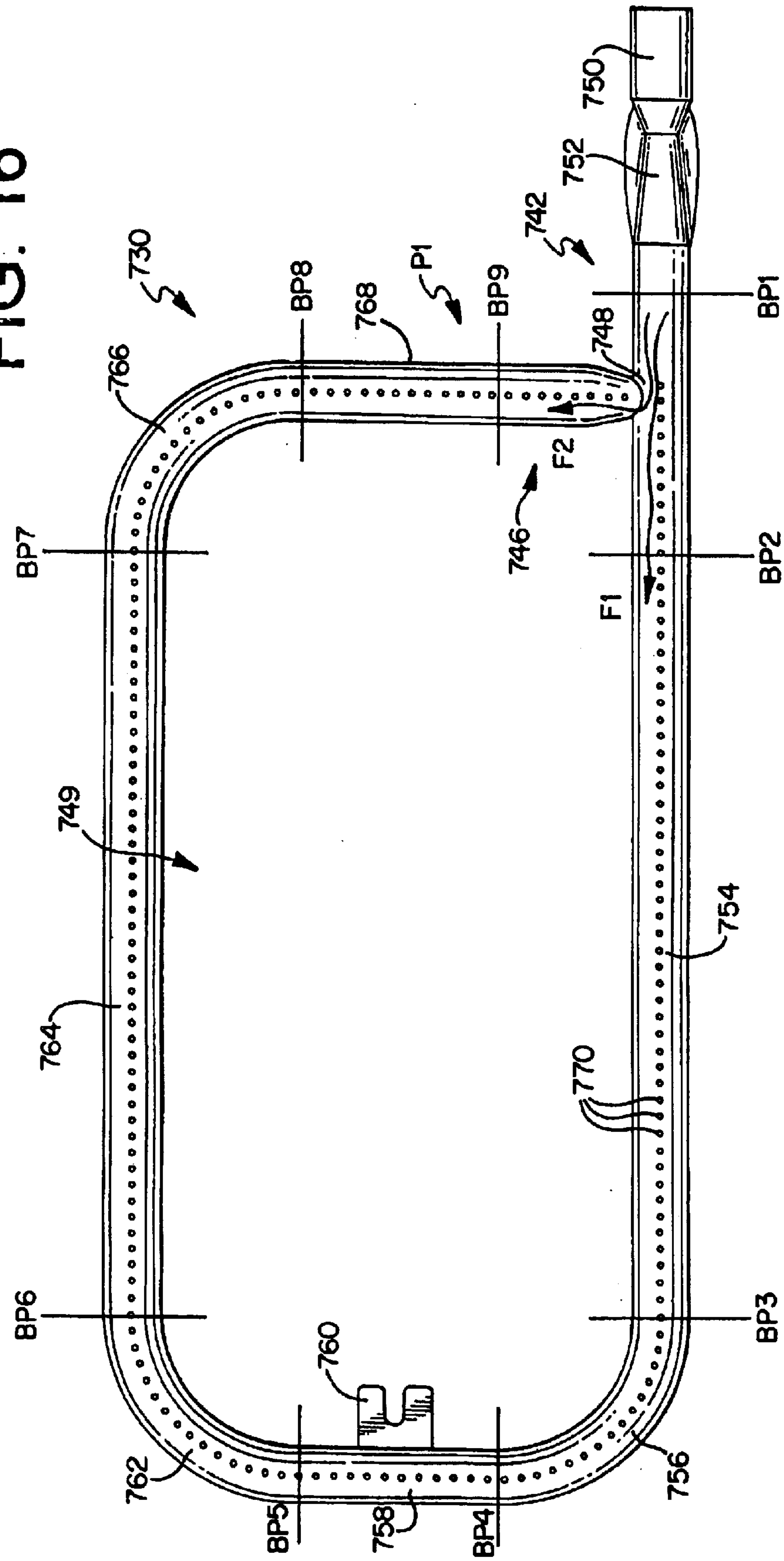
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F2
BP1
BP2
BP3
BP4
BP5
BP6
BP7
BP8
BP9

FIG. 16

CURVILINEAR BURNER TUBE

CROSS-REFERENCE TO RELATED APPLICATIONS

Not Applicable.

FEDERALLY SPONSORED RESEARCH OR DEVELOPMENT

Not Applicable.

TECHNICAL FIELD

The present invention relates to a burner tube for use with a cooking chamber. More specifically, the present invention relates to an elongated curvilinear burner tube having a union region that forms a continuous, multi-directional passageway for the flow of fuel.

BACKGROUND OF THE INVENTION

The popularity of gas barbecue grills and gas outdoor cooking devices has increased tremendously over the last twenty-five years. In contrast to charcoal barbecue grills, gas barbecue grills employ a burner assembly that requires a combustible fluid, for example, propane or natural gas, as a fuel source. Barbecue grills with gas burner elements have proven extremely popular with consumers because they provide controlled, uniform heat distribution. In addition, gas burner assemblies are relatively simple to operate and generally require less maintenance and clean-up time.

Conventional gas burner assemblies typically include a plurality of linear burner tubes, control valves, and a manifold. Each burner tube has a first end and a second end, and a plurality of fuel outlet ports spaced between the first and second ends. The first end of the burner tube is connected to a control valve which meters the flow of fuel. The first end and the control valve are connected to the manifold which is linked to a fuel source, for example, a propane tank. Therefore, multiple burner tubes extend from the manifold. The second end of the burner tube is closed or crimped such that fuel cannot flow past the second end. Accordingly, fuel from the fuel source flows in only one linear path, from the first end to the second end of the burner tube.

Conventional burner assemblies require specific construction and assembly that are susceptible to higher cost and related limitations. First, due to the fact multiple burner tubes are required to form a burner assembly, the material, labor, and assembly costs are significant. These costs are compounded by the fact that each burner tube may require a separate inlet assembly, including a venturi element and a control valve. Further, because the second end of burner tubes are closed or crimped, the first end of each burner tube must be connected to a manifold, thereby limiting the configuration of the burner assembly. Consequently, the versatility of conventional burner assemblies is reduced because such assemblies cannot be uniquely configured or utilized in a wide variety of cooking chambers.

An example of a burner assembly susceptible to the limitations identified above is U.S. Pat. No. 5,676,048 to Schroeter et al. As shown in FIGS. **2** and **11** therein, a burner assembly **17** is formed from the combination of a linear burner tube **18** and two "L-shaped" burner tubes **24**. The linear burner tube **18** has a first end **19** and a closed or crimped second end **20**. Referring to FIG. **12**, the L-shaped burner tube **24** has a primary member **25**, a secondary member **28**, and a curved elbow segment **31**. The first end

26 of the L-shaped burner tube **24** is open, while the second end **30** is closed. Consequently, in either burner tube **18**, **24**, fuel is constrained to flow in a single path—from the first end to the closed second end.

Another example of a burner assembly with the concerns identified above is U.S. Pat. No. 5,890,482 to Farnsworth et al. As shown in FIG. **2**, the burner assembly is formed from the combination of six (6) burner tubes **14**. Each burner tube has a venturi element, an inlet valve assembly, a first series of outlet ports, and a second series of outlet ports. Referring to FIG. **3**, the burner tube **14** has a first segment **44**, a second segment **42**, and a curved elbow segment **46**. The first segment **44** is open while the second segment **42** has a closed end. Accordingly, in the burner tubes **14**, fuel flows from the first end to the closed second end.

Yet another example of a burner assembly of the prior art construction is U.S. Pat. No. 6,102,029 to Schlosser et al., which is assigned to the Assignee of the present invention. As shown in FIGS. **3–5**, the burner assembly **10** generally comprises a first burner tube **21**, a second burner tube **22**, a third burner **23**, and a crossover tube **24**. The second burner tube **22** is positioned between the first and second burner tubes **21**, **23** to form a burner grid **20**. Each burner tube **21**, **22**, **23** has a first end with a venturi assembly **32** connected to a control valve **30** of the manifold **16**. The second end **25** of the first, second, and third burner tubes **21**, **22**, **23** is closed. A crossover tube **24** ports with an orifice **28** located upstream of the second end **25** in the first and second burner tubes **21**, **22**. The crossover tube **24** is in fluid communication with only the first burner tube **21** and the third burner tube **23**. Accordingly, the crossover tube **24** serves as a pilot tube for either the first or third burner tube **21**, **23**. The closed, second end **25** of the second burner tube **22** has a flange **40** that is adapted to be received by a stock connection **42** attached to the crossover tube **24**. Since the second burner tube **22** is not in fluid communication with the crossover tube **24**, the second burner tube **22** only receives fuel from the manifold **16**. Therefore, in the second burner tube **22**, fuel can only flow from the first end to the second end.

Therefore, there is a need for a continuous burner assembly formed from a burner tube wherein fuel can flow in multiple paths or directions throughout the burner tube. Also, there is a definite need for a continuous burner assembly which is compact and capable of being employed in a wide variety of cooking chambers. In addition, there is considerable need for a continuous burner assembly with a single inlet valve assembly to minimize the overall size of the burner assembly while providing an enlarged burner flame area.

The present invention is provided to solve these and other deficiencies.

SUMMARY OF THE INVENTION

The present invention relates to a burner for use with a cooking chamber. More specifically, the present invention relates to a continuous burner constructed from an elongated burner tube having a proximal segment, a distal segment, and a terminal end in fluid connection with a union region of the proximal segment. Due to the fluid connection between the terminal end and the union region, the burner has a curvilinear configuration and defines a multi-directional passageway for the flow of fuel throughout the burner.

The proximal segment is adapted to be connected to a fuel source, i.e., a fuel tank. The distal segment is downstream of the proximal segment. The terminal end is connected to the burner tube at a union or interference region of the proximal segment. The connection between the terminal end and the union region forms a continuous burner tube with a multi-directional passageway. This means that fuel from the fuel source can flow throughout the burner tube, including the proximal segment, the distal segment, the union region, and the terminal end. Specifically, fuel can flow from the proximal segment through the union region and into and through the terminal end. The burner tube has a plurality of fuel outlet ports or apertures from which flames extend. An ignitor is used to ignite fuel that has exited the outlet ports along the burner tube to form a burner flame area.

The burner tube can have a variety of configurations, including a generally obround or rectangular configuration. Preferably, the distal segment has at least one curvilinear portion, which facilitates the connection of the terminal end with the union region. Due to the mating of the terminal end with the proximal segment, the burner tube defines an enclosed central region. The terminal end is connected to the union region whereby the continuous, integral burner tube is formed. The connection between the terminal end and the union region is facilitated by the curvilinear portion. The terminal end can have a necked portion with a tapered diameter, and a mating portion. The mating portion is either partially or entirely received by an aperture in the union region. Once received by the aperture, the terminal end is in fluid communication with the union region of the proximal segment. The fluid communication between the union region and the mating portion defines a passageway or control volume for fuel to flow throughout the burner tube.

In accord with the invention, the burner tube is in a first position **P1** wherein the terminal end is connected to the union region. Due to the curvilinear configuration of the distal segment, the terminal end is biased towards the union region. This biasing causes the terminal end to be lockingly engaged to, or secured with the union region in the first position **P1**. In a second position **P2**, the terminal end is unconnected or disengaged from the union region and due to the biasing described above, a portion of the terminal end extends past the union region. Also, in the second position **P2**, the terminal end is vertically misaligned with a plane defined by the burner tube. The second position **P2** generally represents an unassembled status of the burner tube. Once aligned with the aperture, the biasing of the burner tube will cause the terminal end to lockingly engage the union region.

In the first position **P1**, fuel flows from the fuel source in an initial flow path through the proximal segment and into the union region. Flow separation occurs generally within the union region. A first flow path **F1** flows past the union region and downstream to the distal region. Because the terminal end is in fluid communication with the union region, a second flow path **F2** flows past the union region and downstream into the terminal end. Therefore, fuel from the fuel source can flow in one of two distinct paths, downstream into the distal region or downstream into the terminal end.

In further accord with the invention, the terminal end has a mating portion that is in fluid communication with the aperture of the union region. The mating portion can be received by the aperture. Structure of the mating portion can extend past the aperture such that an edge or wall of the mating portion extends into the union region. This results in alteration of the fuel flow in the union region. As a result, a first portion of fuel flows through the union region and downstream into the distal region and a second portion of fuel flows through the union region and downstream into the terminal end. The geometry of the mating portion and the degree or amount that the mating portion extends past the aperture affects the flow of the fuel in the burner tube.

Other features and advantages of the invention will be apparent from the following specification taken in conjunction with the following drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a perspective view of a barbecue grill assembly showing a first burner tube of the invention;

FIG. **2** is a top plan view of the first burner tube of FIG. **1**;

FIG. **3** is a partial cross-section of the first burner tube taken along line **3**—**3** of FIG. **2**, showing a first connection between a terminal end and a union region;

FIG. **4** is a partial cross-section of the first burner tube taken along line **4**—**4** of FIG. **3**;

FIG. **5** is a partial cross-section of the first burner tube taken along line **3**—**3** of FIG. **2**, showing a second connection between the terminal end and the union region;

FIG. **6** is a partial cross-section of the first burner tube taken along line **3**—**3** of FIG. **2**, showing a third connection between the terminal end and the union region;

FIG. **7** is a partial cross-section of the first burner tube taken along line **7**—**7** of FIG. **6**;

FIG. **8** is a partial cross-section of the first burner tube taken along line **3**—**3** of FIG. **2**, showing a fourth connection between the terminal end and the union region;

FIG. **9** is a partial cross-section of the first burner tube taken along line **9**—**9** of FIG. **8**;

FIG. **10** is a partial cross-section of the first burner tube taken along line **3**—**3** of FIG. **2**, showing a fifth connection between the terminal end and the union region;

FIG. **11** is a partial cross-section of the first burner tube taken along line **11**—**11** of FIG. **10**;

FIG. **12** is a partial cross-section of the first burner tube taken along line **3**—**3** of FIG. **2**, showing a sixth connection between the terminal end and the union region;

FIG. **13** is a partial cross-section of the first burner tube taken along line **13**—**13** of FIG. **12**;

FIG. **14** is a partial cross-section of the first burner tube taken along line **3**—**3** of FIG. **2**, showing a seventh connection between the terminal end and the union region;

FIG. **15** is a partial cross-section of the first burner tube taken along line **15**—**15** of FIG. **14**; and,

FIG. **16** is a top plan view of a second burner tube of the invention.

DETAILED DESCRIPTION OF THE INVENTION

While this invention is susceptible of embodiment in many different forms, there is shown in the drawings and will herein be described in detail preferred embodiments of the invention with the understanding that the present disclosure is to be considered as an exemplification of the principles of the invention and is not intended to limit the broad aspect of the invention to the embodiments illustrated.

A barbecue grill assembly **10** is shown in FIG. **1**. The barbecue grill assembly **10** generally includes a cooking chamber **12** and a support frame assembly **14**. The frame assembly **14** is adapted to provide support to the cooking chamber **12**. The cooking chamber **12** includes a cover **16** hingeably connected to a firebox **18**. The barbecue grill assembly **10** further includes a first work surface **20** and a second work surface **22**, each operably connected to a transverse member **24** of the support frame assembly **14**. The firebox **18** has an interior geometry or configuration defined by a first wall **126**, a second wall **27**, a front wall **28**, and a rear wall **29**. As shown in FIG. **1**, the first and second walls **26**, **27** are sloped or curved.

An elongated burner tube **30** is positioned generally within the firebox **18** of the cooking chamber **12**. The burner tube **30** has a multi-directional configuration which results in passageways for the flow of fuel throughout the burner tube **30**. The burner tube **30** has a geometry similar to the interior geometry of the firebox **18** whereby the burner tube **30** is received by the firebox **18**. Because the burner tube **30** can be configured to match the configuration of the firebox **18**, the utility and versatility of the burner tube **30** is increased. Preferably, the burner tube **30** is a cylindrical element with a circular cross-section with an inner wall diameter and an outer wall diameter. The burner tube **30** is connected to a fuel source (not shown) to define a pathway for flow of the fuel. The burner tube **30** is positioned generally between a grid or grate **32** and a bottom wall (not shown) of the firebox **18**. A portion of the burner tube **30** extends through a port or opening **34** in the proximal sidewall **26** of the firebox **18**. An ignitor **38** is used to ignite fuel as it flows through the burner tube **30**.

Referring to FIG. **2**, the burner tube **30** has a curvilinear configuration with proximal segment **42**, a curvilinear distal segment **44**, and a terminal end **46**. The proximal segment **42** is adapted to be connected to a fuel source, i.e., a fuel tank. The distal segment **44** is downstream of the proximal segment **42**, meaning that fuel flows from the proximal segment **42** to the distal segment **44**. Unlike conventional burner tubes, the terminal end **46** connects to, or mates with the burner tube **30** at a union or interface region **48** of the proximal segment **42**. Thus, the union region **48** is a junction zone between the terminal end **46** and the proximal segment **42**. The connection between the terminal end **46** and the union region **48** forms a continuous burner tube or burner loop **30** wherein fuel flows in two distinct paths—through the distal segment **44** and through the terminal end **46**. Described in a different manner, the terminal end **46** is in fluid communication with the proximal segment **42** at the union region **48** forming a multi-directional passageway that permits the flow of fuel between the proximal segment **42** and the terminal end **46**. Described in yet another manner, the connection between the terminal end **46** and the union region **48** forms a control volume with multi-directional paths for the flow of fuel. Although shown as having a "P-shaped" or "D-shaped" configuration, the configuration and dimensions of the burner tube **30** can vary. For example, the burner tube **30** can have a round, square, or elliptical configuration.

As shown in FIG. **1**, the burner tube **30** is positioned within the firebox **18** such that a portion of the proximal segment **42** extends through an aperture **34** in the second wall **27** of the firebox **18**. Consequently, the distal segment **44** of the burner tube **30** is cooperatively positioned with the first wall **26** of the firebox **18**. An inlet port **52** and a venturi element **54** of the proximal segment **42** are positioned beyond the firebox **18**, and the inlet port **52** is connected to the fuel source. A control valve can be employed to regulate the supply of fuel from the fuel source. Accordingly, fuel from the fuel source passes through the proximal segment **42** and downstream to the distal segment **44** and the terminal end **46**. Since the inlet port **52** is connected to the fuel source, no manifold is required for operation of the burner tube **30**.

The distal segment **44** has at least one curvilinear portion **56**, which contributes to the generally obround or rectangular configuration of the burner tube **30**. As shown in FIG. **2**, the distal segment **44** has three curvilinear portions **56**, however, the precise number of such portions varies with the overall configuration of the burner tube **30**. For example, the burner tube **30** can have an oval or elliptical configuration in which there would be a single, generally continuous curvilinear portion **56**. In addition, the degree or amount of curvature varies with the overall configuration of the burner tube **30**. The curvilinear portion **56** facilitates the connection of the terminal end **46** with the union region **48**. Due to the mating of the terminal end **46** with the proximal segment **42**, the burner tube **30** defines an enclosed central region **58**. Although shown as having a generally obround or rectangular configuration, the central region **58** can have a round, square, or elliptical configuration.

The burner tube **30** has a plurality of outlet ports or apertures **60** from which a flame extends. Due to its multi-directional configuration, the continuous burner tube **30** forms an enlarged burner flame area compared to a conventional linear burner. The ignitor **38** (see FIG. **1**) is used to ignite the fuel that has flowed through the through the burner tube **30** and exited the ports **60**. As shown in FIG. **2**, the outlet ports **60** are linearly aligned along the burner tube **30** to discharge fuel in a substantially vertical direction, meaning perpendicular to the plane of the burner tube **30**. As a result, the outlet ports **60** are positioned in an upper portion of the burner tube **30** such that the resulting flame is directed towards the grate **32**. Preferably, the outlet ports **60** are positioned at an upper portion of the burner tube **30** when viewed in cross section. Alternatively, the ports **60** are positioned in a side portion of the burner tube **30**. Preferably, the outlet ports **60** are positioned throughout the burner tube **30**, including the union region **48**. The first or initial outlet port **60***a* is spaced a distance from the venturi element **54**. Due to its multi-directional configuration, the continuous burner tube **30** forms an enlarged flame area, which is the sum of flames extending the outlet ports **60**, that is consistent with the interior geometry of the firebox **18**.

The distal segment **44** includes a bracket **61**, that in combination with the aperture **50** in the proximal wall **26** of the firebox **18**, supports the burner tube **30** within the firebox **18**. A ramp or ledge (not shown) of the first wall **26** includes a fastener (not shown) that is cooperatively positioned for engagement with the bracket **61**. The bracket **61** and the aperture **50** combine to support the burner tube **30** in an elevated position with respect to the bottom wall of the firebox **18**. Preferably, the bracket **61** is welded to the burner tube **30**.

Referring to FIGS. **3** and **4**, the terminal end **46** is in fluid connection with the union region **48** thereby forming the continuous burner tube **30**. Due to the fluid connection, the burner tube **30** has a multi-directional passageway for the continuous flow of fuel. This structural aspect of the burner tube **30** provides multi-directional fuel flow through the tube **30**. The connection between the terminal end **46** and the union region **48** is facilitated by the curvilinear portion **56**. The terminal end **46** has a necked portion **62** with a tapered diameter that ceases at a mating portion **64**. Accordingly, the diameter of the mating portion is less than the diameter of the necked portion **62**. The mating portion **64** is either partially or entirely received by an aperture **66** in the union region **48**. Once received by the aperture **66**, the terminal end **46** is in fluid communication with the union region **48** of the proximal segment **42**. The fluid communication between the union region **48** and the mating portion **64** defines a loop or passageway for fuel to flow throughout the burner tube **30**.

To ensure the fluid communication, the diameter of the aperture **66** is equivalent to the diameter of the mating portion **64**. Preferably, the diameter of the aperture **66** and the mating portion **64** is less than the diameter of the burner tube **30** at the union region **48**. As shown in FIGS. **3** and **4**, the aperture **66** and the mating portion **64** have a circular configuration when viewed in cross-section. Alternatively, the aperture **66** and the mating portion **64** can have an oval or elliptical configuration. A force can be applied to the terminal end **46** to deform it radially inward such that the mating portion **64** has an oval or elliptical configuration.

As shown in FIG. **2**, the terminal end **46** is connected to the union region **48** at a connection angle θ, defined as the angle between the union region **48** and the terminal end **46**. Although shown as approximately 90 degrees, the connection angle θ varies between 10 to 90 degrees along with the design parameters of the burner tube **30**. The configuration of the burner tube **30** will be altered as the connection angle θ is varied. For example, when the connection angle θ is between 30–60 degrees the burner tube **30** has a "V-shaped" junction between the union region **48** and the terminal end **46**. In addition, the geometry of the aperture **66** will vary with the connection angle θ. Where the connection angle θ is approximately 90 degrees, the aperture **66** will have a circular configuration. Where the connection angle θ is less than 90 degrees, the aperture **66** will have an elliptical configuration.

As shown in FIG. **4**, the burner tube **30** has a first wall **68** and a second wall **70**. Preferably, the aperture **66** is formed in the first wall **68** and has an leading edge **66*a*** and a trailing edge **66*b***. The mating portion **64** has a leading edge wall **64*a*** and a trailing edge wall **64*b***. The leading edge wall **64*a*** extends past the leading edge **66*a*** of the aperture **66** and into the union region **48**, and the trailing edge wall **64*b*** extends past the trailing edge **66*b*** of the aperture **66** and into the union region **48**. Preferably, the trailing edge wall **64*b*** extends further into the internal area of the union region **48** than the leading edge wall **64*a***. As a result, the mating portion **64** has an angled or flared tip **76**. The degree or amount that the trailing edge wall **64*b*** extends past the trailing edge **66*b*** of the aperture **66** varies with the design parameters of the burner tube **30**. As discussed below, the geometry of the mating portion **64** and/or tip **76** can affect the flow of the fuel through the burner tube **30**.

Referring to FIGS. **2**–**4**, the burner tube **30** is in a first position **P1** wherein the terminal end **46** is connected to the union region **48**. Due to the curvilinear configuration of the distal segment **44**, the terminal end **46** is biased towards the union region **48**. This biasing causes the terminal end **46** to be lockingly engaged to, or secured with the union region **48** in the first position **P1**. Consequently, a fastening member or weldment is not required to maintain the connection between the terminal end **46** and the union region **48**. In a second position **P2**, the terminal end **46** is unconnected or disengaged from the union region **48** and due to the biasing described above, a portion of the terminal end **46** extends past the union region **48**. Described in a different manner, a portion of the terminal end **46** extends past the first wall **68** and/or the second wall **70** of the burner tube **30**. Described in yet another manner, a portion of the terminal end **46** extends past a longitudinal axis of the union region **48**. Also, in the second position **P2**, the terminal end **46** is vertically misaligned with a plane defined by the burner tube **30**. Described in a different manner, the terminal end **46** passes either above or below the plane defined by the burner tube **30**. The second position **P2** generally represents an unassembled status of the burner tube **30**. To move the burner tube **30** from the second position **P2** to the first position **P1**, the biasing resulting from the curvilinear configuration must be overcome. First, a sufficient amount of force must be applied to the terminal end **46** such that it retracts and clears the first wall **68**. Once this force is applied, a second force must be applied to the terminal end **46** to align it with the aperture **66**. Once aligned with the aperture **66**, the biasing of the burner tube **30** will cause the terminal end **46** to lockingly engage the union region **48**.

In the first position **P1**, fuel flows from the fuel source in an initial flow path F through the proximal segment **42** and into the union region **48**. Flow separation occurs generally within the union region **48**. As indicated by the streamlines in FIG. **4**, a first fuel portion, as indicated by second flow path **F2**, flows past the union region **48** and downstream to the distal region **44**. Because the terminal end **46** is in fluid communication with the union region **48**, a second fuel portion, as indicated by first flow path **F1**, flows past the union region **48** and downstream into the terminal end **46**. Described in different terms, the flow path F of the fuel begins to diverge at the union region **48**, with the second flow path **F2** flowing through the distal region **44** and the first flow path **F1** flowing through the terminal end **46**. Since the terminal end **46** is in fluid communication with the proximal segment **42** in the first position **P1**, the fuel can flow in one of two distinct paths—downstream into the distal region **44** or downstream into the terminal end **46**. In the second position **P2**, there is no connection between the terminal end **46** and the union region **48** and as a result, the first flow path **F1** will not flow into the terminal end **46** from the union region **48**.

In another preferred embodiment shown in FIG. **5**, the terminal end **146** has a mating portion **164** with at least one opening **180**. The opening **180** is adapted to permit an amount of the second flow path **F2** to flow past the union region **48** and downstream to the proximal segment **42**. Preferably, the opening **180** is positioned in a trailing wall **164*b*** of the mating portion **164**. The precise amount of the second flow path **F2** that passes through the opening **180** depends upon a number of factors, including but not limited to the degree of insertion of the mating portion **164** in the union region **148**, the configuration of the opening **180**, and the flow rate of the fuel from the fuel source.

In another preferred embodiment shown in FIGS. **6** and **7**, the terminal end **246** has a necked portion **262** with a tapered diameter that terminates in a mating portion **264**. The terminal end **246** is connected to the aperture **266** of the union region **248**. Referring to FIG. **7**, a leading edge wall **264*a*** of the mating portion **264** is positioned coincident with a leading edge **266*a*** of the aperture **266**. A trailing edge wall **264*b*** of the mating portion **264** is positioned coincident with a trailing edge **266*b*** of the aperture **266**. Accordingly, the mating portion **264** does not extend past the aperture or into the union region **248**. Preferably, the mating portion **264** is coped to fit against the first wall **268** of the burner tube **230**.

In the first position **P1**, the terminal end **246** is in fluid communication with the union region **248**. Due to the curvilinear configuration of the burner tube **230**, the terminal end **230** is biased towards the union region **248**. Accordingly, the mating portion **264** is lockingly engaged or secured to the union region **248** without the use of a fastener or weldment. In the first position **P1**, as indicated by the streamline F, fuel flows from the fuel source through the proximal segment **242** of the burner tube **230** and into the union region **248**. As explained above, a second flow path **F2** flows past the union region **248** and downstream to the distal region (not shown) of the burner tube **230**. Because the terminal end **246** is in fluid communication with the union region **248**, a first flow path F1 flows past the union region **248** and downstream into the terminal end **246**. Described in different terms, the flow of fuel F begins to diverge at the union region **248**, with the second flow path F2 flowing to the distal region and the first flow path F1 flowing through the terminal end **246**.

In another preferred embodiment shown in FIGS. **8** and **9**, the terminal end **346** has a necked portion **362** with a tapered diameter that terminates in a mating portion **364**. The terminal end **346** is connected to the aperture **366** of the union region **348**. Referring to FIG. **9**, a leading edge wall **364***a* of the mating portion **364** is positioned coincident with a leading edge **366***a* of the aperture **366**. A trailing edge wall **364***b* of the mating portion **364** extends past a trailing edge **366***b* of the aperture **366** and into the union region **348**. An insertion element **380** is positioned between the trailing edge **366***b* of the aperture **366** and the trailing edge **364***b* of the mating portion **364**. The insertion element **380** is an "L-shaped" structure that is adapted to alter the fluid flow in the union region **348**. The insertion element **380** is affixed to a first wall **368** of the burner tube **330** such that a portion of the insertion element **380** extends into the aperture **366**. The degree or amount that the insertion element **380** extends into the aperture **366** varies with the design parameters of the element **380** and the burner tube **330**.

In the first position PI, the terminal end **346** is in fluid communication with the union region **348**. Due to the curvilinear configuration of the burner tube **330**, the terminal end **330** is biased towards the union region **348**. Accordingly, the mating portion **364** is lockingly engaged or secured to the union region **348** without the use of a fastener or weldment. In the first position **P1**, as indicated by the streamline F, fuel flows from the fuel source through the proximal segment **342** of the burner tube **330** and into the union region **348**. As explained above, a second flow path F2 flows past the union region **348** and downstream to the distal region (not shown) of the burner tube **330**. Because the terminal end **346** is in fluid communication with the union region **348**, a first flow path F1 flows past the union region **348** and downstream into the terminal end **346**. Described in different terms, the flow of fuel begins to diverge at the union region **348**, with the second flow path F2 flowing to the distal region and the first flow path F1 flowing through the terminal end **346**. The geometry of the insertion element **380** causes a flow disturbance in the union region **348** which alters the flow of the first and second flow paths F1, F2. Compared to the embodiment shown in FIGS. **7** and **8**, the insertion element **380** increases the quantity of fuel flowing through the terminal end **346**.

In another preferred embodiment shown in FIGS. **10** and **11**, the terminal end **446** has a necked portion **462** with a tapered diameter that terminates in a mating portion **464**. The terminal end **446** is connected to the aperture **466** of the union region **448**. Referring to FIG. **11**, a leading edge wall **464***a* of the mating portion **464** is positioned coincident with a leading edge **466***a* of the aperture **466**. A trailing edge wall **464***b* of the mating portion **464** is positioned coincident with a trailing edge **466***b* of the aperture **466**. Accordingly, the mating portion **464** does not extend past the aperture or into the union region **548**. Preferably, the mating portion **564** is coped to fit against the first wall **568** of the burner tube **530**. A vane **580** is positioned within the burner tube **530**, preferably in the union region **548**. The vane **580** is a curvilinear structure adapted to alter the fuel flow in the

union region **548**. The vane **580** is affixed to a lower portion **582** of the burner tube **530** and extends upward from the lower portion **582**. The vane **580** has a leading edge **580***a* and a trailing edge **580***b*. As shown in FIG. **11**, the leading edge **580***a* is positioned in the union region **548** upstream of the aperture **566** and the trailing edge **580***b* is positioned at a midpoint of the aperture **566**. However, the precise location of the vane **580** within the union region **548** can vary. Referring to FIG. **10**, the height of the vane **580** is approximately one-half of the diameter of the burner tube **530**. However, the height of the vane **480** can vary such that the vane **480** occupies a greater or lesser amount of the union region **448**.

In the first position **P1**, fuel F flows from the fuel source through the proximal segment **442** of the burner tube **430** and into the union region **448**. Flow separation occurs at the leading edge **480***a* of the vane **480**, where the leading edge **480***a* is the separation point. As indicated by the streamlines of FIG. **11**, the initial flow path F is separated into two distinct flow paths F1, F2. The second flow path F2 flows along and past an outer surface **480***c* of the vane **480** and downstream to the distal region (not shown) of the burner tube **430**. Because the terminal end **446** is in fluid communication with the union region **448**, the first flow path F1 flows along and past an inner surface of the vane **480** and downstream into the terminal end **446**. Described in different terms, the vane **480** causes a flow disturbance in the union region **448** which alters the initial flow path F into the first and second flow paths F1, F2, with the second flow path F2 flowing to the distal region and the first flow path F1 flowing through the terminal end **446**.

In another preferred embodiment shown in FIGS. **12** and **13**, a curvilinear vane **580** is positioned within the burner tube **530**, preferably in the union region **548**. The vane **580** is a curvilinear structure adapted to alter the fuel flow in the union region **548**. The vane **580** has a leading edge **580***a* and a trailing edge **580***b*. As shown in FIG. **13**, the leading edge **580***a* is positioned in the union region **548** downstream of the leading edge **566***a* of the aperture **566**. The trailing edge **580***b* is positioned adjacent the trailing edge **566***b* of the aperture **566**. Referring to FIG. **12**, the height of the vane **580** is approximately one-half of the diameter of the burner tube **530**. However, the height of the vane **580** can vary such that the vane **580** occupies a greater or lesser amount of the union region **548**.

In the first position **P1**, fuel F flows from the fuel source through the proximal segment **542** of the burner tube **530** and into the union region **548**. Flow separation occurs at the leading edge **580***a* of the vane **580**, where the leading edge **580***a* is the separation point. As indicated by the streamlines of FIG. **13**, the initial flow path F is separated into two distinct flow paths F1, F2. The second flow path F2 flows along and past an outer surface **580***c* of the vane **580** and downstream to the distal region (not shown) of the burner tube **530**. Because the terminal end **546** is in fluid communication with the union region **548**, the first path F1 flows along and past an inner surface of the vane **580** and downstream into the terminal end **546**. Described in different terms, the vane **580** causes a flow disturbance in the union region **548** which alters the initial flow path F into the first and second flow paths F1, F2, with the second flow path F2 flowing to the distal region and the first flow path F1 flowing through the terminal end **546**.

In another preferred embodiment shown in FIGS. **14** and **15**, a valve **680** is positioned within the burner tube **630**, preferably in the union region **648**. The valve **680** is moveable between a closed position wherein fuel F is prevented from flowing past the union region **648**, and an open position wherein fuel F is able to flow past the union region **648**. Preferably, the valve **680** is spring-loaded such that the valve **680** is in the closed position when fuel F is not flowing to the burner tube **630**. Once fuel F is supplied to the burner tube **630**, the valve **680** moves to the open position, thereby allowing fuel F to flow past the union region **748** and downstream to the distal region and the terminal end **646**. The precise position of the valve **680**, meaning degree of opening, can vary with the spring constant used in the valve **680**.

In the first position P1 and when the valve **680** is in the open position, fuel F flows from the fuel source through the proximal segment **642** of the burner tube **630** and into the union region **648**. As indicated by the streamlines of FIG. **15**, the initial flow path F is separated into two distinct flow paths F1, F2. The second flow path F2 flows around the valve **680**, including the leading and trailing edges **680***a,b* of the valve **680**, and downstream to the distal region (not shown) of the burner tube **630**. Because the terminal end **646** is in fluid communication with the union region **648**, the first flow path F1 flows downstream into the terminal end **646**. Described in different terms, the valve **680** causes a flow disturbance in the union region **648** which alters the initial flow path F into the first and second flow paths F1, F2, with the second flow path F2 flowing to the distal region and the first flow path F1 flowing through the terminal end **646**.

In another preferred embodiment shown in FIG. **16**, the burner tube **730** generally comprises a first end **742** and a second end **746** in fluid connection to a union region **748**. The fluid connection between the second end **746** and the union region **748** forms the continuous burner tube or burner loop **730**. Thus, the union region **748** defines an interface zone between the second end **746** and the burner tube **730**. Described in a different manner, the union region **748** is a junction zone between the second end **746** and the burner tube **730**. Due to the connection between the second end **746** and the union region **748**, the burner tube **730** defines an enclosed central region **749**. The first end **742** has an inlet port **750** that is adapted to be connected to a control valve of a fuel source, i.e., a fuel tank. In this manner, the first end **742** is adapted to facilitate the transfer of fuel from the fuel source to the burner tube **730**. A venturi element **752** is positioned adjacent the inlet port **750**.

The union region **748** is a generally linear segment that is downstream from the first end **742**. The union region **748** is bounded by the first burner position BP1 and the second burner position BP2. Adjacent to the union region **748** is the first linear segment **754**, which is bounded by the second burner position BP2 and the third burner position BP3. A first curvilinear segment or elbow **756** is adjacent to the first linear segment **754**. The first curvilinear segment **756** is bounded by the third burner position BP3 and the fourth burner position BP4. Adjacent to the first curvilinear segment **756** is a first transition segment **758**, which is bounded by the fourth burner position BP4 and the fifth burner position BP5. The first transition segment **758** includes a bracket **760** adapted to support the burner tube **730** within the firebox **18**. Preferably, the bracket **760** is welded to the burner tube **730**.

A second curvilinear segment **762** is adjacent to the first transition segment **758**. The second curvilinear segment **762** is bounded by the fifth burner position BP5 and the sixth burner position BP6. Adjacent to the second curvilinear segment **762** is a second linear segment **764**, which is bounded by the sixth burner position BP6 and the seventh burner position BP7. A third curvilinear segment **766** is adjacent to the second linear segment **764**. The third curvilinear segment **766** is bounded by the seventh burner position BP7 and the eighth burner position BP8. Adjacent to the third curvilinear segment **766** is a second transition segment **768**, which is bounded by the eighth burner position BP8 and the ninth burner position BP9. The second end **746** is adjacent to the second transition segment **768** and is bounded by the ninth burner position BP9 and the union region **748**. A plurality of outlet ports **770** are spaced along the burner tube **730**. As shown in FIG. **6**, the outlet ports **770** begin in the union region **748** and continue downstream throughout the burner tube **730**. The radius of curvature of the curvilinear segments **756**, **762**, **766** can vary with the design parameters of the burner tube **730**; however, the curvilinear segments **756**, **762**, **766** must be configured to permit the second end **746** to be in fluid communication with the union region **748**.

Because the second end **746** is connected to the union region **748** to form a continuous burner tube **730**, fuel from the fuel source can flow in two distinct paths. These flow paths result from the second end **746** being in fluid communication with the union region **748**. In contrast, conventional burners have a single flow path which begins at the inlet and continues through the burner to the terminal end, which is closed or crimped. As shown in FIG. **16**, a first fuel portion, as indicated by flow path F1, flows past the union region **748** and downstream to the first linear segment **754**. An amount of this first flow path F1 exits the ports **770** in the first linear segment **754**, while a remaining quantity flows downstream to the first curvilinear segment **756**. An amount of this remaining first flow path F1 exits the ports **770** in the first curvilinear segment **756** and a remaining quantity flows downstream to the first transition segment **758**. An amount of this remaining first flow path F1 exits the ports **770** in the first transition segment **758** and a remaining quantity flows downstream to the second curvilinear segment **762**. An amount of this remaining first flow path F1 exits the ports **770** in the second curvilinear segment **762** and a remaining quantity flows downstream to the second linear segment **764**. This flow path continues until all of the first flow path F1 exits the ports **266**.

The second fuel portion, as indicated by flow path F2, flows past the union region **748** and downstream into the second end **746**. An amount of the second flow path F2 exits the ports **770** in the second end **746** and a remaining quantity flows downstream to the second transition segment **768**. An amount of this remaining second flow path F2 exits the ports **770** in the second transition segment **768** and a remaining quantity flows downstream to the third curvilinear segment **766**. An amount of this remaining second flow path F2 exits the ports **770** in the third curvilinear segment **766** and a remaining quantity flows downstream to the second linear segment **764**. This flow path continues until a portion of the first flow path F1 converges and/or mixes with a portion of the second flow path F2. For example, the remnants of the first flow path F1 can combine with the remnants of the second flow path F2 within the third curvilinear segment **766**. The point at which the first and second flow paths F1, F2 converge depends upon a number of factors, including but not limited to the flow rate of the fuel and the configuration and dimensions of the burner tube **730**.

In another preferred embodiment (not shown), the continuous burner tube has a generally "B-shaped" configuration. The burner tube has a lengthened proximal segment which accommodates the connection of a primary burner tube and a secondary burner tube. Consistent with the above disclosure, the distal end of the primary burner tube is in fluid communication with a first union region of the proximal segment. The secondary tube is generally "C-shaped" with a first and a second end. The first end of the secondary tube is in fluid communication with a second union region, and the second end of the secondary tube is in fluid communication with a third union region.

Due to the three junctions at the union regions, the B-shaped burner tube has multi-directional passageways. Accordingly, fuel from the fuel source can flow in multiple directions throughout the continuous burner tube and as a result, the flame area emanating from the burner tube is increased.

The present invention provides a novel method for distributing fuel through a continuous burner tube. Referring to FIG. **2**, the proximal segment **42** is connected to a fuel source. Fuel enters the burner tube **30** at the inlet port **52**. A regulator (not shown) is utilized between the fuel source and the proximal segment **42** to regulate and/or modulate the flow of fuel. Preferably, a manifold is not required. The fuel forms an initial flow path F and flows downstream through the venturi element **54** and into the union region **48** of the proximal segment. As shown in FIGS. **4**, **8**, and **10** and due to the fluid connection between the union region **48** and the terminal end **46**, separation of the initial flow path F occurs in the union region **48** with the formation of a first flow path **F1** and a second flow path **F2**. The first flow path **F1** flows past the union region **48** and downstream to the distal region **44**. The second flow path **F2** flows past the union region **48** and downstream to the terminal end **46**. As a result, two distinct flow paths **F1**, **F2** are formed to distribute fuel throughout the burner tube **30**. Fuel from each flow path **F1**, **F2** is combusted upon exiting the outlet ports **60**. The burner tube **30** has a burner flame area, which is the collective measure of the flames exiting the plurality of outlet ports **60**. Due to the multi-directional configuration of the continuous burner tube **30**, the flame area is enlarged to match the geometry of the firebox **18**, thereby increasing the efficiency and effectiveness of the burner tube **30**.

Preferably, at some point downstream of the union region **48**, the first and second flow paths **F1**, **F2** converge. The precise location of the convergence depends upon a number of factors, including but not limited to the flow rate of the fuel and the configuration of the burner tube **30**.

The burner tube of the present invention provides a number of significant advantages over conventional burners. First, the connection between the terminal end and the union region forms a continuous burner tube having a multi-directional passageway for the flow of fuel. This allows for multiple flow paths of fuel throughout the burner tube, which in turn increases fuel distribution throughout the burner tube. Also, the burner tube has only one inlet valve, which permits a direct connection to the fuel source without the need of a manifold. This reduces the material costs and eases the assembly of the grill assembly having the burner tube. In addition, the continuous burner tube forms an enlarged flame area with a geometry that is similar to the interior geometry of the firebox resulting in uniform heat distribution to the grate positioned in the firebox. This reduces the need for multiple burner tubes in the firebox. Third, due to the curvilinear segments and the resulting biasing, the terminal end is connected to the union region without the use of a fastener. This reduces the assembly process and as a result, the material and labor costs are reduced.

Another benefit of the present invention relates to shipping and packaging concerns of the burner tube and the

barbecue grill assembly. Unlike conventional burners, the burner tube of the present invention is easily and fully assembled by connecting the terminal end to the union region. Consequently, the burner tube can be packaged and shipped fully assembled generally eliminating further assembly by the end user or the retailer.

While the specific embodiments have been illustrated and described, numerous modifications come to mind without significantly departing from the spirit of the invention and the scope of protection is only limited by the scope of the accompanying claims.

We claim:

1. A burner for a barbecue grill comprising:

a continuous curvilinear burner having a proximal segment, a distal segment, and, a terminal end with a mating portion connected to an aperture of a union region of the proximal segment to form a multi-directional passageway, wherein the mating portion has a reduced diameter to mate with the aperture.

2. The burner of claim **1** wherein the connection between the terminal end and the union region forms a continuous burner wherein the proximal segment, the distal segment, and the terminal end are in fluid communication.

3. The burner of claim **1** wherein the distal segment has at least one curvilinear portion adapted to direct the terminal end substantially transverse to the proximal segment.

4. The burner of claim **1** wherein a generally rectangular central region is defined by the connection between the terminal end and the union region.

5. The burner of claim **1** wherein the proximal segment is adapted to be connected to a fuel source such that a portion of fuel from the fuel source flows from the proximal segment downstream through the terminal end in a continuous path.

6. The burner of claim **1** further comprising a plurality of outlet ports positioned throughout the burner.

7. A burner assembly for use with a cooking chamber, the burner assembly comprising:

a fuel source;

a burner tube having a proximal segment connected to the fuel source, the proximal segment having a union region, the union region having an aperture; a distal segment; a plurality of outlet ports; and, a terminal end with a mating portion in fluid communication with an aperture of the union region, the mating portion having a reduced outer diameter to mate with the aperture.

8. The burner assembly of claim **7** wherein the connection between the terminal end and the aperture forms a continuous burner tube.

9. The burner assembly of claim **8** wherein a first portion of fuel from the fuel source flows through the union region and downstream to the distal segment.

10. The burner assembly of claim **9** wherein a second portion of fuel from the fuel source flows through the union region and downstream to the terminal end.

11. The burner assembly of claim **7** wherein an initial flow of fuel diverges in the union region into a first flow path and a second flow path, the first flow path flowing downstream through the distal segment and the second flow path flowing downstream through the terminal end.

12. The burner assembly of claim **7** wherein the distal segment has at least one curvilinear portion.

13. The burner assembly of claim **7** wherein the burner tube defines an enclosed central region, the central region having a generally rectangular configuration.

14. The burner assembly of claim **7** wherein the terminal end is coped to match an outer wall of the union region.

15. A burner assembly for use with a barbecue grill, the burner assembly comprising:

a fuel source;

a burner tube having a proximal segment connected to the fuel source, the proximal segment having a linear union region with an aperture, the burner tube further having a distal segment, a plurality of outlet ports, and a terminal end with a mating portion removably connected to the union region at the aperture, the mating portion is cooperatively dimensioned with an outer wall of the union region wherein the mating portion has a reduced diameter compared to the diameter of the terminal end.

16. The burner assembly of claim **15** wherein the terminal end is biased into connection with the union region at the aperture.

17. The burner assembly of claim **15** wherein the terminal end is biased towards the proximal segment.

18. The burner assembly of claim **15** wherein the terminal end is coped to match an outer wall of the union region about the aperture.

19. The burner assembly of claim **15** wherein the distal segment has at least one curvilinear portion.

20. A burner assembly for use with a barbecue grill, the burner assembly in fluid communication with a fuel source comprising:

a burner tube having a proximal segment connected to the fuel source, the proximal segment having a union region with an aperture, the burner tube further having a distal segment, a plurality of outlet ports, and a terminal end with a mating portion removably connected to the union region at the aperture, wherein the mating portion has a reduced diameter compared to the diameter of the terminal end to mate with the aperture.

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