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Peterson et al.

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[54] **FUEL BURNER**

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[58] **Field of Search** 431/181, 182, 183, 184, 431/187, 188; 239/407, 416.4, 416.5, 239/423, 404

[56] **References Cited**

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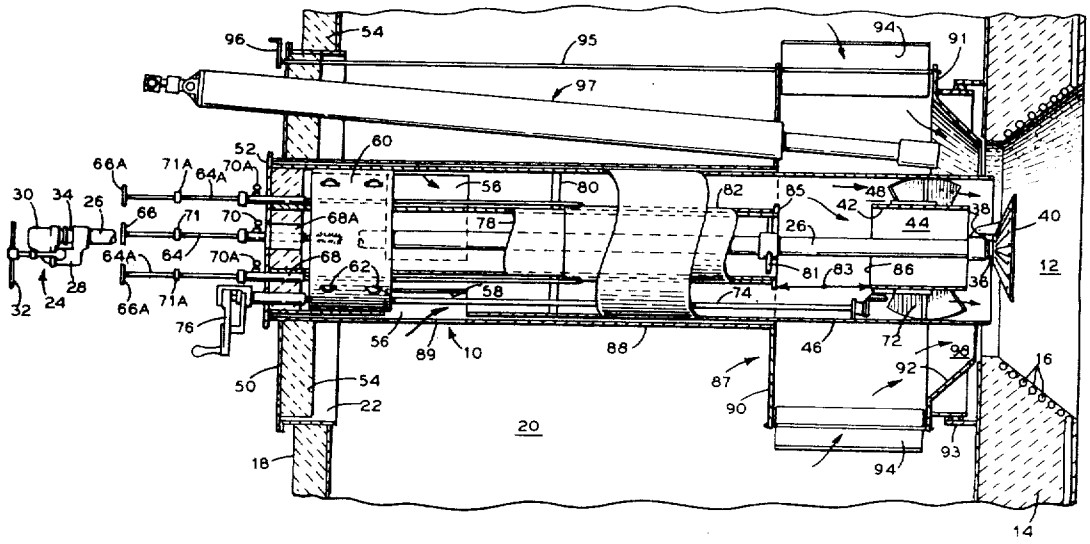
[57] **ABSTRACT**

An improved fluent fuel burning apparatus including three individual airflow passages and separate means for apportioning the flow of combustion air among the passages so as to achieve complete combustion of the fuel while reducing the formation of nitric oxides.

5 Claims, 2 Drawing Figures



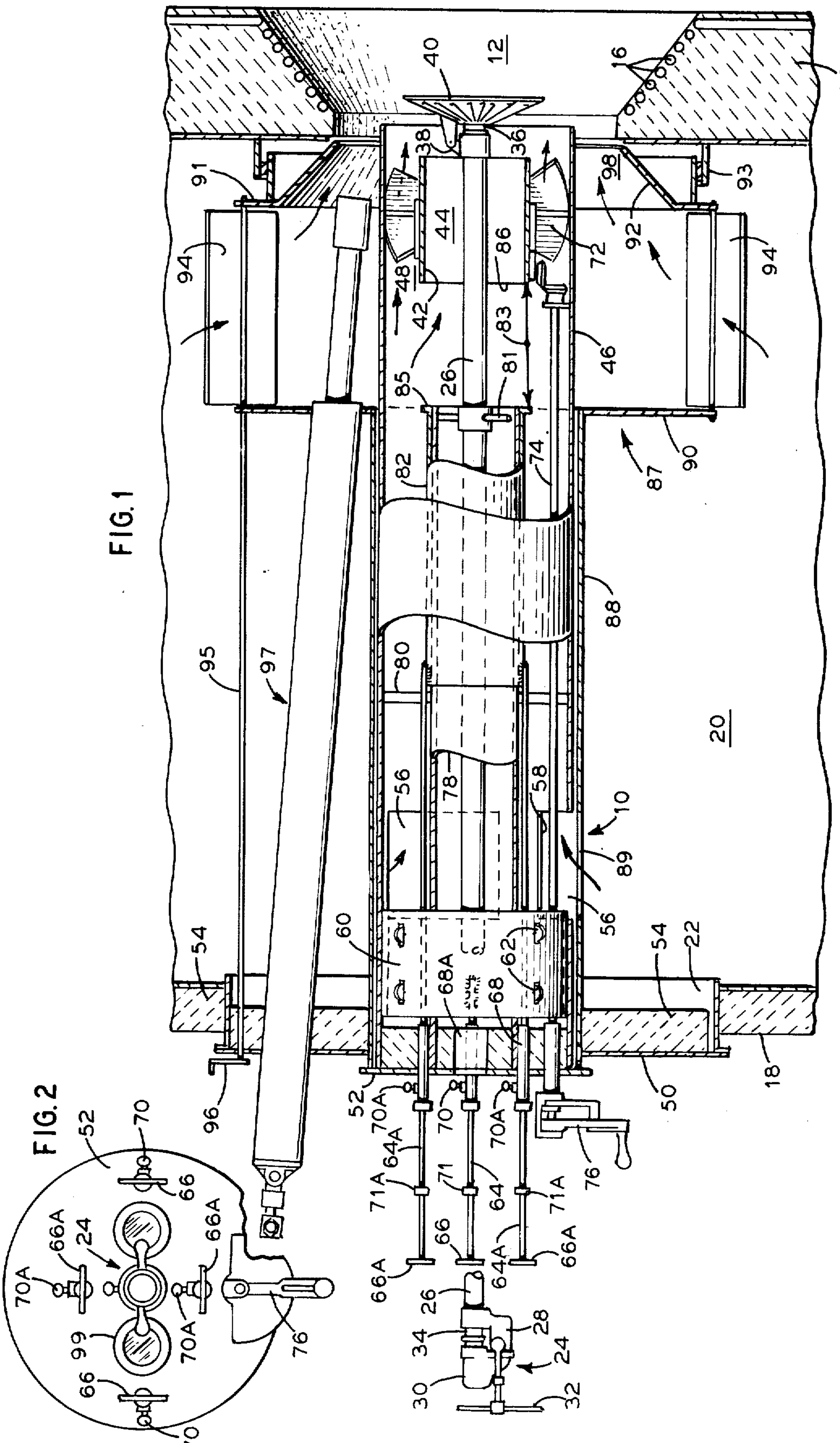


FIG.1

FIG.2

FUEL BURNER

BACKGROUND OF THE INVENTION

The present invention relates to fuel burners and more particularly to an improved fluent fuel burner for reducing the formation of nitric oxides by lowering the combustion zone temperature and providing a reducing atmosphere in the ignition zone.

There is a present day growing concern with the immediate and long term problems created by the rapid increase in air pollution resulting from the rise in the industrial civilization level throughout the world. With this concern comes an acute awareness that immediate steps must be taken to reverse this upward trend in pollution and great efforts are now being made by public and private economic sectors to develop measures for preventing potentially polluting particles and gases from being discharged into the atmosphere. One such source of atmospheric pollution is the nitrogen oxides (NO_x) present in the stack emission of fossil fuel fired steam generating units. Nitric oxide (NO) is an invisible, relatively harmless gas. However, as it passes through the vapor generator and comes into contact with oxygen, it reacts to form nitrogen dioxide (NO_2) or other oxides of nitrogen collectively referred to as nitric oxides. Nitrogen dioxide is a yellow-brown gas which, in sufficient concentrations is toxic to animal and plant life. It is this gas which may create the visible haze at the stack discharge of a vapor generator.

Nitric oxide is formed as a result of the reaction of nitrogen and oxygen and may be thermal nitric oxide and/or fuel nitric oxide. The former occurs from the reaction of the nitrogen and oxygen contained in the air supplied for the combustion of fossil fuel whereas the latter results from the reaction of the nitrogen contained in the fuel with the oxygen in the combustion air.

The rate at which thermal nitric oxide is formed is dependent upon any or a combination of the following variables; (1) flame temperature, (2) residence time of the combustion gases in the high temperature zone and (3) excess oxygen supply. The rate of formation of nitric oxide increases as flame temperature increases. However, the reaction takes time and a mixture of nitrogen and oxygen at a given temperature for a very short time may produce less nitric oxide than the same mixture at a lower temperature, but for a longer period of time. In vapor generators of the type hereunder discussion wherein the combustion of fuel and air may generate flame temperatures in the order of 3,700°F, the time-temperature relationship governing the reaction is such that at flame temperatures below 2,900°F no appreciable nitric oxide (NO) is produced, whereas above 2,900°F the rate of reaction increases rapidly.

The rate at which fuel nitric oxide is formed is principally dependent on the oxygen supply in the ignition zone and no appreciable nitric oxide is produced under a reducing atmosphere; that is, a condition where the level of oxygen in the ignition zone is below that required for a complete burning of the fuel.

It is apparent from the foregoing discussion that the formation of thermal nitric oxide can be reduced by reducing flame temperatures in any degree and will be minimized with a flame temperature at or below 2,900°F and that the formation of fuel nitric oxide will be inhibited by providing a reducing atmosphere in the ignition zone.

With the advent of stricter emission controls, manufacturers of fuel burning equipment have been actively seeking methods of limiting the amount of pollutants which are formed from the combustion of fossil fuel.

U.S. Pat. No. 3,788,796 issued to Krippene et al. and assigned to the Assignee of the present invention discloses a technique used with relation to burning pulverized fuel and which achieves a reduction in the formation of nitric oxide and results in a more complete burning of the fuel.

SUMMARY OF THE INVENTION

The present invention provides an apparatus for reducing the formation of nitric oxide while achieving a more complete burning of fluent fuel than has heretofore been possible.

Accordingly, an apparatus is provided for the burning of fluent fuels wherein at least a part of the apparatus is disposed within a windbox to which combustion air is supplied and which is formed between adjacent burner and furnace walls of a vapor generating unit. The burner wall is formed with an access opening for admitting that portion of the apparatus which normally resides in the windbox whereas the furnace wall is formed with a burner port which accommodates the combining of fuel and air into a combustible mixture and the ignition thereof. The apparatus includes an open ended member disposed within the windbox and forming a central passageway of circular cross-section coaxially arranged with and having its discharge end opening to the burner port. A conduit having a portion thereof concentrically spaced about the open ended member forms therebetween a first annular passageway discharging into the burner port. A register concentrically spaced about a portion of the conduit defines therewith a second annular passageway discharging into the burner port. Means are provided within the windbox to apportion the combustion air between the aforementioned passageways. Nozzle means extend through the windbox to introduce a fluent fuel into the burner port in a pattern substantially symmetrical with the axis of the port.

An object of the invention is to provide a fluent fuel burning apparatus wherein initial burning is conducted in a fuel rich climate to cause a reducing zone which inhibits the formation of fuel nitric oxide and provides the lower peak flame temperatures required to minimize the formation of thermal nitric oxide.

Another object of the invention is to limit the initial mixing of the fluent fuel and air to cause a recirculating zone which creates a flame stabilizing effect.

A further object of the invention is to admit the remaining air required for complete combustion along a flow pattern which surrounds the reducing and stabilizing zones and eventually mixes with the fluent fuel to complete its combustion.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a segmental side view incorporating fluent fuel burning apparatus embodying the invention.

FIG. 2 is an end view of a segment of the apparatus depicted in FIG. 1.

DESCRIPTION OF THE PREFERRED EMBODIMENT OF THE INVENTION

The embodiment illustrated in the drawings and hereinafter described is related to a fuel burning appa-

ratus associated with a liquid fuel burner. It will be understood, however, that the invention is equally applicable for use with a gaseous fuel burner.

Referring to FIG. 1, reference numeral 10 identifies a fuel burning apparatus which is arranged to fire through a circular burner port 12, the latter being lined by refractory and formed as a frusto-conical throat diverging toward the furnace side of the front wall 14 and being fluid cooled by the tubes 16. A burner or outer wall 18 is spaced from the furnace front wall 14 to form a windbox 20 therebetween. The burner wall 18 includes an access opening 22 which admits that portion of the fuel burning apparatus normally residing within the windbox 20.

In the illustrated embodiment there is shown a liquid fuel burner 24 of the type disclosed in U.S. Pat. No. 2,414,459 issued to J. Fletcher and assigned to the Assignees of the present invention, and including a guide tube 26 extending through the windbox 20 in coaxial relation with the burner port 12. The guide tube 26 has its inlet end threadably engaged to a yoke assembly 28, the latter being connected to liquid fuel and atomizing fluid supply lines (not shown). The discharge end of yoke 28 is connected to a transition member 30 for the through flow of fuel and atomizing fluid. A leakproof fit between the yoke 28 and the member 30 is achieved by introducing a gasket (not shown) between the mating surfaces and applying pressure with a locking device 32. A fuel tube or nozzle 34 extends through the guide tube 26 and out of the distal end thereof. The nozzle 34 is connected at its inlet end to the transition member 30 and is provided at its outlet end with an atomizing assembly including a sprayer plate 36 which introduces the atomized fuel into the burner port 12 in a pattern substantially symmetrical with the axis of the port. The distal end of the guide tube 26 includes a support ring 38 and an air deflecting device 40 attached thereto. The deflector 40 is in the form of a truncated cone and is concentrically disposed about the central axis of the burner throat 12 and includes an opening to accommodate the passage therethrough of the sprayer plate 36.

In accordance with the invention there is provided an open ended member 42 disposed in spaced surrounding relation with a portion of the liquid fuel burner guide tube 26 and forming a central passageway 44 of circular cross-section coaxially arranged with and having its discharge end opening to the burner port 12. A conduit 46 extends through the windbox 20 and has an outlet end portion thereof concentrically spaced about the open ended member 42 to form therebetween a first annular passageway 48 discharging into the burner port 12. The conduit 46 has its inlet end projecting through the closure member 50 which covers the burner access opening 18; the inlet end is in turn covered by a circular plate member 52. The burner wall 18, the closure and plate members 50 and 52 are covered with insulating material 54 so as to inhibit conductive heat loss there-across. Combustion air is admitted to the conduit 46 through one or more circumferentially spaced slots 56 preferably located in near proximity to the burner wall 18. The slots 56 are preferably of arcuate rectangular configuration and are separated by ribs 58 formed by the conduit wall. A sleeve like member 60 is located within the conduit 46 and is equipped with wheels 62 partially recessed in the sleeve wall and contacting the ribs 58 thus facilitating the movement of the sleeve member 60 across the slots 56 so as to cover a part or all of the area of the slots 56 thereby providing the means for regulating the quantity of combustion air admitted to the conduit 46. The sleeve member 60 has an external diameter slightly smaller than the internal diameter of the conduit 46 and an axial length slightly greater than the axial length of the slots 56. A pair of positioning rods 64, horizontally spaced from one another, have their respective distal end weldably connected to the sleeve member 60 and the opposite end terminating outside of the windbox 20 and are fitted with handle portions 66 to allow adjustment of the position of the sleeve 60 from without the windbox. The positioning rods 64 are supportingly guided by a respective tube member 68, the latter extends through the plate 52 and its insulation cover and is provided with a locking device 70 to fixedly hold the positioning rod 64 so as to maintain the selected position of sleeve 60 with respect to the slots 56. The distance between the trailing edge of the slots 56 and the windbox end of the tube members 68 is substantially equal to the axial length of the sleeve member so that the slots 58 will be fully exposed when the sleeve 60 abuts on the windbox end of the tubes 68 thereby allowing maximum flow of combustion air into conduit 46. Stops 71 in the form of collars are provided on the positioning rods 64 and are fixedly located so as to abut the outside end face of the tube members 68 when the sleeve member 60 completely covers the slots 56, shutting off substantially all of the combustion air flow into the conduit 46.

A plurality of vanes 72 are arranged in surrounding relationship to the open ended member 42 and are located within the first annular passageway 48, the vanes 72 are equidistantly spaced and preferably linked to one another so as to be collectively and simultaneously adjustable through a shaft member 74 operatively connected thereto and terminating outside of the windbox 20 and connected to a manually operated handle 76. The vanes 72 have the principal function of imparting a rotational component to the combustion air flowing through the first annular passageway 48.

A tubular member 78 has one end thereof rigidly connected to the plate 52 and extends through the conduit 46 in spaced coaxial relation therewith and in spaced surrounding relation with the burner nozzle guide tube 26 and axially spaced from the inlet end of the open ended member 42. A plurality of circumferentially spaced struts 80 are located midway along the axial length of the tubular member 78 and provide support for the conduit 46 through the member 78, the latter is also used to support the guide tube 26 through a plurality of struts 81 which are collared around the guide tube 26 and abut against the inside wall of the tubular member 78.

A sleeve like member 82 is slidably fitted over the forward end portion of member 78 and is movable to change the spacing 83 between its forward end flange 85 and the inlet end face 87 of the member 42 so as to provide the means for regulating the quantity of combustion air flowing through the central passageway 44. The sleeve member 82 is shown in its fully retracted position and the spacing 83 is wide open thereby allowing a maximum quantity of combustion air to pass from the conduit 46 to the central passageway 44.

A pair of positioning rods 64A, vertically spaced from one another, have their respective distal end weldably connected to the rear end portion of the

sleeve member **82** and their opposite end terminating outside of the windbox **20** and are fitted with handle portions **66A** to allow positioning of the sleeve member **82** from without the windbox. The positioning rods **64A** are supportingly guided by a respective tube member **68A**, the latter extends through the plate **52** and its insulation cover and is provided with a locking device **70A** to fixedly hold the positioning rod **64A** so as to maintain the selected position of sleeve member **82** with respect to the open ended member **42.** The struts **80** have the added function of serving as a backstop for the sleeve member **82** so that the spacing **83** is at its maximum dimension when the rear end face of sleeve member **82** abuts against the struts **80.** Stops **71A** in the form of collars are provided on the positioning rods **64A** and are fixedly located so as to abut the outside end of the tube member **68A** when the forward end flange **85** rests against the inlet end **86** of the open ended member **42** thereby closing the spacing **83** and shutting off substantially all of the combustion air flow into the open ended member **42.**

A register assembly **87** is spaced about the conduit **46** and has one end rigidly connected to the plate **52** and the opposite end opening into the burner port **12.** The register assembly **87** includes a cylindrical housing **88** disposed in adjacent surrounding relation to the conduit **46** and including a portion thereof fitted with slots **89** having substantially the same configuration as the slots **56** and being located in superposed fashion thereto so as to provide an unimpeded flow path into the conduit **46.** The distal end of the housing **88** is rigidly connected to the inner periphery of an annular plate member **90** which forms one of the walls defining the inlet to the register assembly **87,** the other wall being formed by an annular plate member **91** fitted with a converging frusto-conical section **92.** The plate **91** and the section **92** cooperate with the conduit **46** to form an annular passageway **98** therebetween.

The members **93** supportingly connect the plate **91** and the section **92** to the front wall **14.** A plurality of dampers or register doors **94** are circumferentially spaced and pivotally mounted between the walls **90** and **91** and are adapted to pivot between open and closed positions thereby providing the means for regulating the quantity of combustion air being admitted to the annular passageway **98.** The positioning of the dampers **94** is simultaneously effected through a shaft **95** suitably linked thereto and terminating outside of the windbox **20** and fitted with an operating handle **96.** An ignitor assembly **97** of known type extends through the closure member **50** and the plate member **90** and terminates in the annular passageway **98.**

If desired, the positioning rods **64** and **64A** and the dampers **94** may be suitably geared, linked or otherwise connected so as to be responsive to automatically controlled actuating devices.

FIG. **2** of the illustrated embodiment is an end view of the plate member **52** and the elements situated thereabout such as the handles **66** and **66A** and the locking devices **70** and **70A** associated with the positioning rods used to position the sleeve members which are a feature of the invention. There are also shown a pair of observation doors **99** straddling the liquid fuel burner **24** and the handle **76** associated with the shaft used to regulate the vanes located in the central passageway.

In the operation of the preferred embodiment, liquid fuel is supplied to and atomized within the fuel burner **24** and sprayed into the port **12** in a pattern substantially symmetrical with the axis of the port. The total air required for combustion of the fuel is supplied from the windbox **20** and is distributed among three separate passageways for discharge into the port **12.** The aforementioned passageways being defined as the central passageway **44,** the first annular passageway **48** and the second annular passageway **98.** The quantity of combustion air admitted to each passageway is controlled by separate flow regulating means, i.e., the sleeve member **82** which is adjustable to vary the spacing **83** providing access to the inlet of the central passageway **44;** the sleeve member **60** which is adjustable to vary the opening of the slots **56** providing access to the first annular passageway by way of conduit **46;** and the dampers **94** which are simultaneously adjustable to vary the inlet opening to the register assembly **87** including the second annular passageway **98** formed thereby. In accordance with the invention, the apparatus herein disclosed provides the means whereby initial burning of the fuel is conducted in a reducing zone by adjusting the sleeve member **82** so as to limit the quantity of combustion air being discharged through the central passageway **44.** Means are also provided whereby a flame stabilizing zone is created by adjusting the sleeve member **60** to regulate the quantity of air being admitted to the conduit **46** and discharged through the first annular passageway **48** so as to cause recirculation of air about the outer periphery of the reducing zone. Finally, means are provided whereby the remaining air required for the complete combustion of fuel is regulated by adjusting the dampers **94** and is discharged through the second annular passageway **98** so as to envelop the reducing and stabilizing zones and eventually mix with the fuel to complete its combustion.

Under actual operation, it has been found that maintaining the combustion air which flows through the central passageway **44** within a range of 15 to 30 percent of stoichiometric air and that which flows through the first annular passageway **48** within a range of 5 to 35 percent of stoichiometric air creates a stable ingition zone under a reducing atmosphere and provides lower peak flame temperatures. The combustion air which flows through the second annular passageway **98** is maintained within a range of 50 to 65 percent of stoichiometric air and represents the air needed to complete the combustion of the fuel.

While in accordance with provisions of the statutes there is illustrated and described herein a specific embodiment of the invention, those skilled in the art will understand that changes may be made in the form of the invention covered by the claims, and that certain features of the invention may sometimes be used to advantage without a corresponding use of the other features.

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. In combination with a boundary wall of a furnace, at least one burner port formed in the boundary wall, a burner wall spaced from the boundary wall to form a windbox therebetween to which combustion air is supplied, an open ended member disposed within the windbox and forming a central passageway of circular cross-section coaxially arranged with and having its dis-

charge end opening to said port, conduit means concentrically spaced about said open ended member to form therebetween a first annular passageway discharging into said port, adjustable vane means disposed within said first passageway, a register concentrically spaced about said conduit means to define therewith a second annular passageway discharging into said port, means disposed within said windbox for apportioning the combustion air between said passageways, and nozzle means for introducing a fluent fuel into the port in a pattern substantially symmetrical with the axis of said port.

2. The combination according to claim **1** wherein the means for apportioning the combustion air include having the conduit means formed with a slotted portion and providing sleeve means movable across said slotted portions.

3. The combination according to claim **2** wherein said sleeve means is disposed within the conduit means.

4. The combination according to claim **2** including rotatable means fitted in said sleeve means wall.

5. The combination according to claim **1** wherein the means for apportioning the combustion air include a member coaxially arranged with and facing the inlet end of the central passageway, said last named member being movable along its axis to vary the distance between it and said inlet end.

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