United States Patent

Adams

[15] **3,685,946**

[45] **Aug. 22, 1972**

[54] **COMBUSTION CHAMBER SUPPLEMENTAL AIR SUPPLY ASSEMBLY AND METHOD**

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[22] Filed: **Nov. 12, 1970**

[21] Appl. No.: **88,819**

[52] **U.S. Cl.** **431/8,** 431/190, 431/252

[51] **Int. Cl.**.....**F23c 7/00**

[58] **Field of Search**.....431/8, 10, 252, 190

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[57] **ABSTRACT**

A supplemental air supply assembly and method for transporting and directionally orienting high pressure air impingement on a flame envelope within a combustion chamber. Ambient air is introduced into a fan connected to a conduit which forces inlet air into the combustion chamber. The inlet air is positioned to oppose the flame envelope and is vortexed by a series of angled vanes fastened to the conduit. The air is preheated within an elongated sleeve prior to interaction with the flame envelope. The amount of high pressure inlet air introduced into the chamber is regulated.

20 Claims, 7 Drawing Figures

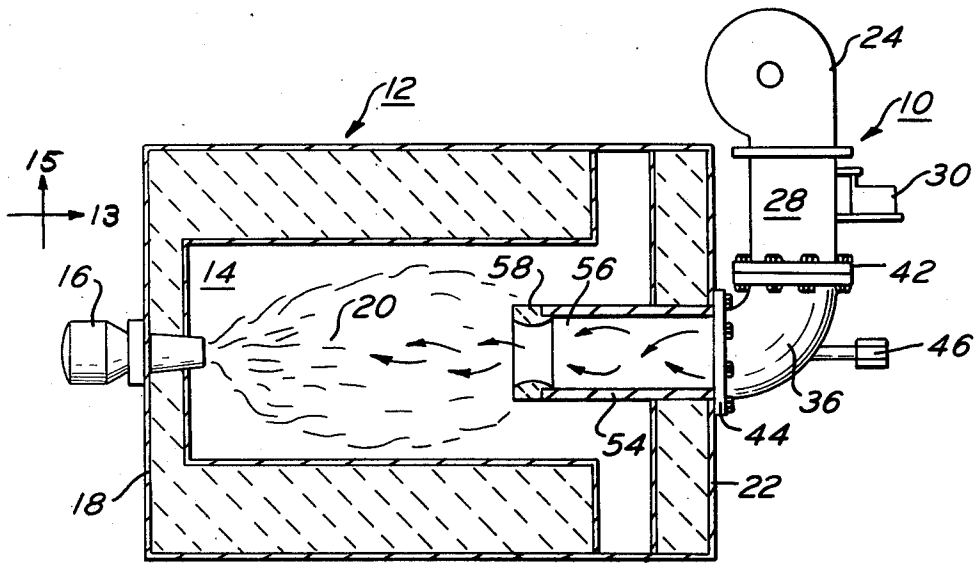


FIG. 1

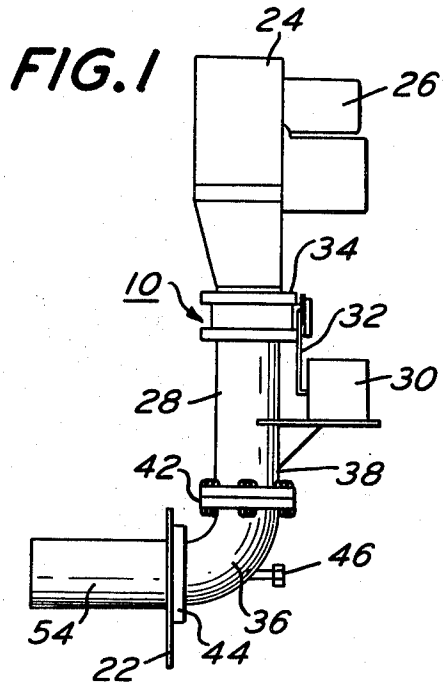
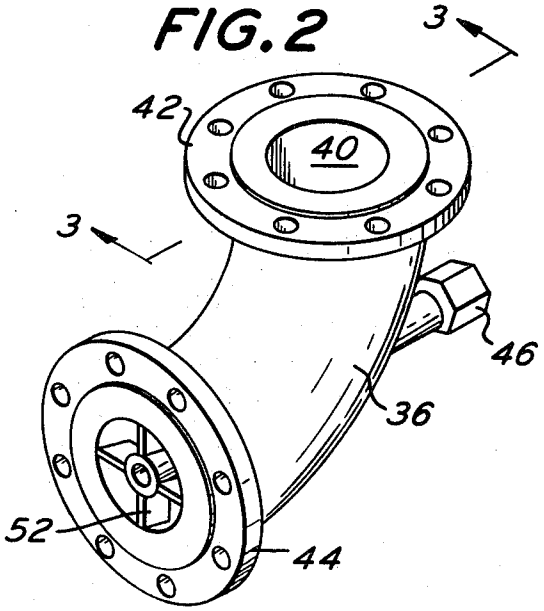


FIG. 2



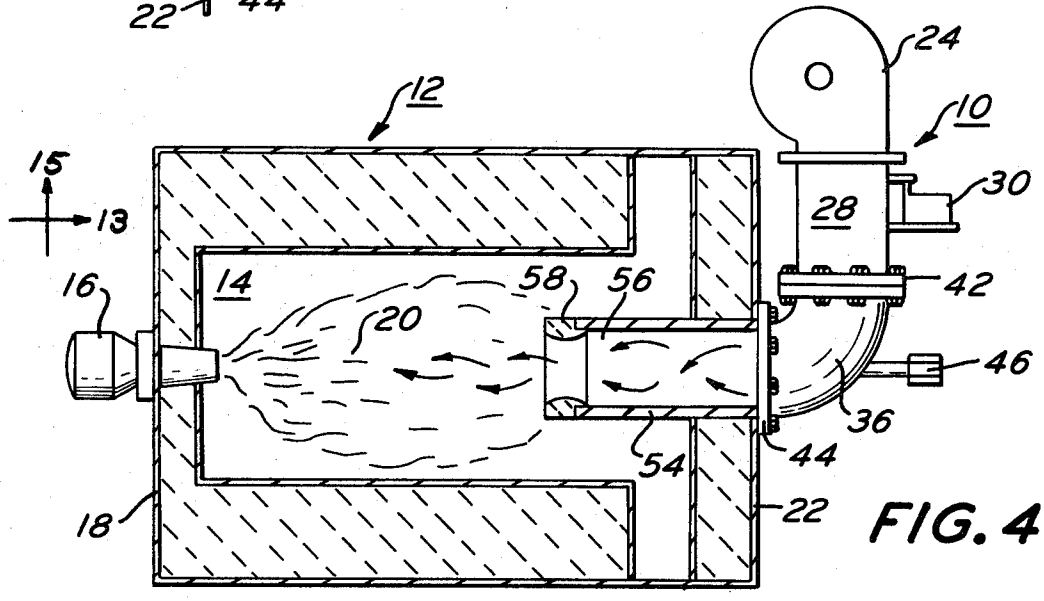


FIG. 4

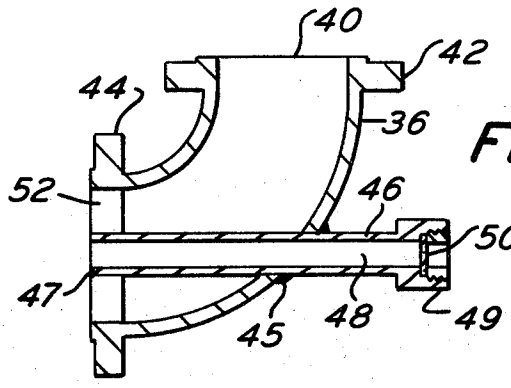


FIG. 3

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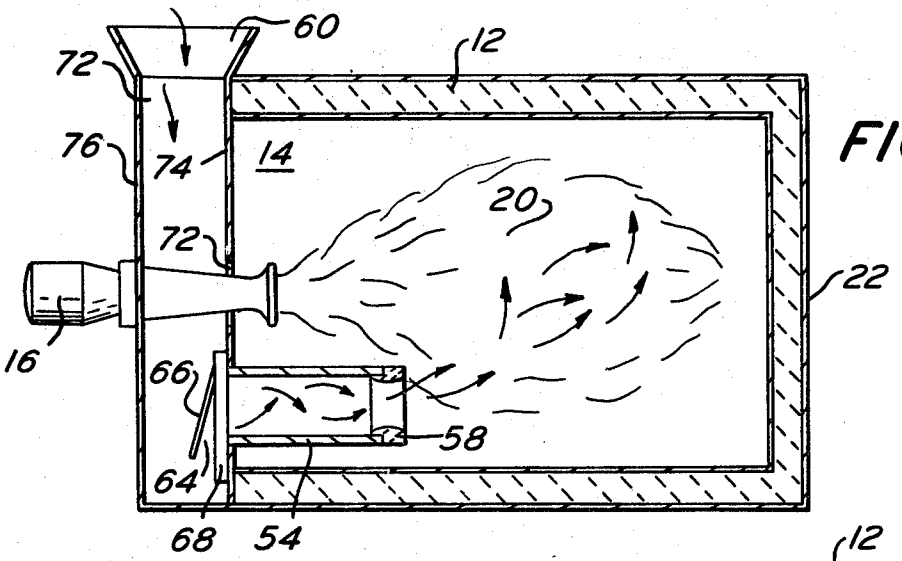


FIG. 5

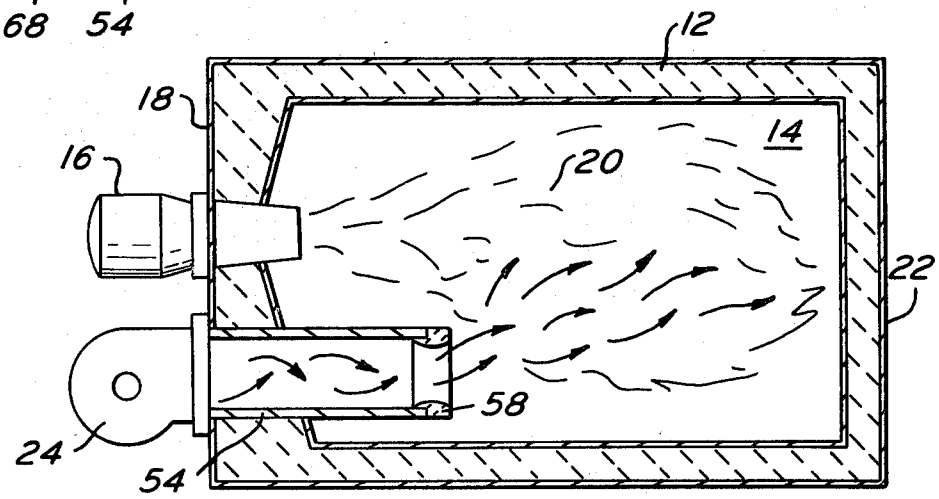


FIG. 6

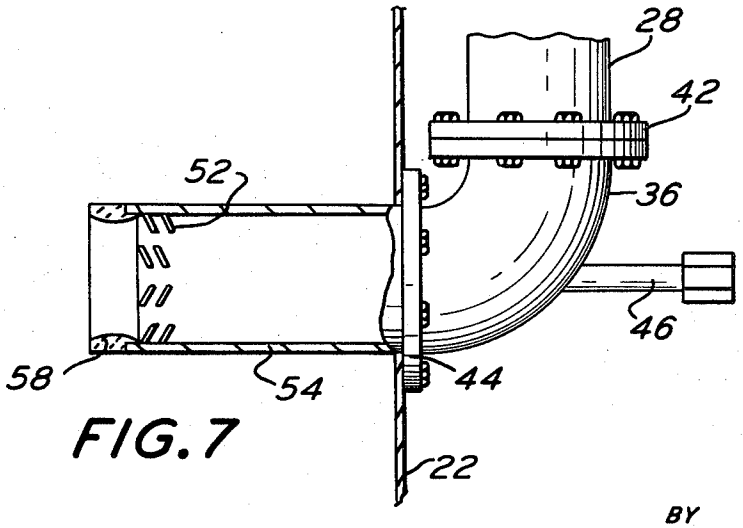


FIG. 7

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COMBUSTION CHAMBER SUPPLEMENTAL AIR SUPPLY ASSEMBLY AND METHOD

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to the field of air supply units for combustion chambers. In particular this invention pertains to an assembly and method of introducing supplemental air into a combustion chamber which is directionally oriented and has a particular streamline contour with respect to a flame envelope.

2. Prior Art

Supplemental air supply assemblies for combustion chambers are known. Some of such assemblies provide for vortexing of the inlet air. However, most of such prior art only increases the turbulence around the periphery of the chambers without substantially increasing the heating efficiency. Some assemblies have countercurrent air flow supply but do not provide for vortexing of the air to wrap the unburned fuel back into the flame envelope.

Preheating of the supplemental air supply is also known. Previous systems have introduced preheated air into a chamber at the periphery or under the flame envelope, but none are known which directly force the inlet air into the flame envelope in a way which will compress the surface area thereby increasing the flame temperature to ensure substantially complete fuel combustion.

SUMMARY OF THE INVENTION

A supplemental air supply assembly and method for increasing fuel combustion efficiency within a combustion chamber. Included within the chamber is a fuel burner which forms a flame envelope having both a longitudinal and transverse dimension. The assembly comprises an air inlet device which extends through the wall of the combustion chamber. The air inlet device obtains ambient air external to the combustion chamber and produces a streamline contour air flow which is both opposed to the longitudinal dimension and forced in the transverse dimension of the flame envelope.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is an elevational view of the supplemental air supply assembly;

FIG. 2 is a perspective view of the elbow sectional element of the assembly showing the vortexing vanes;

FIG. 3 is a cross-section view of the elbow sectional element taken along the section line 3—3 of FIG. 2;

FIG. 4 is a cross-section view of the invention installed in a furnace operation;

FIG. 5 is a cross-section view of an embodiment of the invention utilized in a forced draft windbox boiler;

FIG. 6 is a cross-section view of another embodiment of the invention utilized in an induced draft boiler; and

FIG. 7 is a cross-section view of the elbow sectional element in combination with a preheating air sleeve having angled vanes secured therein to provide vortexed air flow.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to FIGS. 1–4 there is shown a supplemental air supply assembly or air system **10** to increase the fuel combustion efficiency of furnace **12**. Fuel burner **16** extends through furnace side wall **18** into combustion chamber **14** from the external environment. A controlled fuel/air mixture is provided to burner **16** to produce flame front **20** after ignition, which in turn promotes a regulated heat source within chamber **14**. Flame front **20** forms a flame envelope having both a longitudinal **13** and transverse dimension **15** as shown in FIG. **4**. In total, system **10** operates functionally to introduce a preheated air flow supply into chamber **14** being both vortexed and countercurrent to flame front **20**. The quantity of air inserted into furnace **12** is controlled to match the unburned gases and heavy carbon which wraps these compounds into the core of the flame to produce a higher flame temperature within a more compact flame envelope. In other words, by compressing the effective surface area of the flame higher temperatures as well as heat source capabilities are achieved. As will later be described in greater detail, system **10** produces increased flame temperatures, as well as an increase in fuel efficiency through the release of greater radiant heat transfer energy which is proportional to the fourth power of the flame temperature produced.

Supplemental air supply assembly **10** comprises four major systems including fan or blower **24**, damping device **34**, conduit **28**, and preheating air supply ceramic sleeve **54**. Assembly **10** is fixedly located adjacent to furnace **12** to provide an air supply from the external ambient environment. Furnace wall **22** includes an opening passing therethrough and inlet air under pressure may be incorporated into chamber **14** through conduit passage **40** longitudinally **13** opposing and impinging on flame front **20**.

Fan or blower **24** has an inlet opening located external to furnace **12** to intake ambient air and an outlet passage coaxially positioned with respect to conduit **28** to provide a conduit pathway through which the high pressure air may be transferred. Fan **24** may be of the standard centrifugal type whose selection is based on the empiracally derived necessary quantity of air determined for a specific furnace **12** application. In general, blower **24** may consist of a squirrel cage series of vanes or blades mounted on the rim of a wheel. The vanes are generally slanted forward in the direction of rotation of the wheel in such a manner as to provide a maximum discharge of air. It has been empiracally shown that up to **20** percent of the air input at fuel burner **16** must be accommodated by fan **24** in order to obtain maximum burning efficiency within chamber **14**. Selection of proper fans or blowers **24** may be made from a standardized grouping of high pressure air devices well known in the art. Fan **24** is operated by motor **26** which may be wired to a potentiometer at the head end of furnace **12** in conjunction with burner **16** which then governs the fuel/air mixture being input to chamber **14**. Therefore, ambient air intake of fan **24** is exhausted under pressure through conduit **28** and enters furnace **12** through wall **22** as a function of the amount required to maximize fuel combustion efficiency of burner **16**.

The amount of high pressure inlet air being delivered to chamber **14** is regulated either by a control of fan or blower **24** through motor **26** through damping device **34** which is positioned coaxially with the outlet of fan **24** and conduit **28** on opposing ends thereof. Damping device **34**, not shown in detail, may be one of a standard set of assemblies which restrict conduit passage **40** as a function of the amount of inlet air required within chamber **14**. Damping motor **30** operates linkage **32** external to conduit **28** and passes internal to conduit **28** to adjust an air shutter placed within passage **40**. In this manner, the air shutter is angularly rotated within passage **40** to regulate the cross-sectional area of conduit passage **40** and supply the necessary quantity of air. Automatic operation of device **34** may be maintained through a conventional thermostat connected to motor **30**. A thermostat may be connected to a temperature sensing device, such as a thermistor or thermocouple, which measures the temperature of the incoming inlet air within chamber **14**. Device **34** may then be operated automatically through motor **30** as a function of inlet air temperature.

Conduit **28** comprises upper conduit member **38** and elbow section **36** rigidly secured to each other to form a continuous conduit passage **40** terminating on opposing ends at damping device **34** and furnace wall **22**. Functionally, conduit **28** provides a path for the high pressure inlet air from fan **24** or damping device **34** into combustion chamber **14**. Elbow section **36** of conduit **28** is fastened on opposing ends thereof to upper conduit member **38** and furnace wall **22** forming a constant diameter conduit passage **40** therebetween. Section **36** forms a bend providing a normal vector air outlet to that of the incoming air from upper conduit member **38**. This **90** degree bend provides for a tube or peepsight **46** to be incorporated into system **10**, but is not necessary for operation.

Rigid attachment of elbow section **36** to upper conduit member **38** and furnace wall **22** is made through elbow flange **42** and wall flange **44** respectively. Flange attachments may be by bolting, welding or some other means not important to the invention. In this manner ambient air input to fan **24**, as shown in FIG. **4**, may be transported under a high pressure through upper conduit member **38**, elbow section **36** and through an opening in furnace wall **22** into combustion chamber **14** longitudinally opposing or counter-current to flame front **20**.

Section **36**, as depicted in FIGS. **2** and **3** includes a tube or peepsight **46** extending in longitudinal direction **13** through an outer wall of elbow **36** and into conduit passage **40** centrally terminating adjacent to furnace wall **22**. Tube **46** is fastened to the outer wall of section **36** by weld **45** or by bolting. Tube passage **48** extending through peepsight **46** provides for visual observation of flame front **20** to an observer located external to furnace **12**. Passage **48** is covered on tube external end **49** by a disc of high temperature transparent glass **50** to protect the observer.

Tube end **47** of peepsight **46** includes a plurality of vanes **52** rigidly secured to the outer diameter of tube **46** and extending radially to the inner diameter wall of elbow section **36**. Vanes **52** are angled with respect to longitudinal direction **13** to provide a vortex motion for the incoming inlet air. In this manner, inlet air which has been given a longitudinal flow contour velocity is now brought into chamber **14** having a combined motion. System **10**, extending through wall **22** of furnace **12** then obtains inlet air from the ambient environment and provides a streamline air flow contour which opposes flame front **20** longitudinally **13** and in a transverse direction **15**. Dependent on the angularization of vanes **52** and the plane to which they are formed air may be vortexed helically or in a vertical direction within chamber **14**.

In addition it has been found that supply air entering combustion chamber **14** of furnace **12** can substantially increase the fuel burning efficiency by incorporating preheated inlet air. Ceramic sleeve **54** attached to elbow **36** through wall flange **44** extends longitudinally into chamber **14** through furnace wall **22**. Sleeve **54** is directed toward flame front **20** to provide a path constraint for the inlet air as well as a preheating capability. Ceramic sleeve **54** is tubular and made of a material such as silicon carbide which has a high termal conductivity and can withstand the elevated temperatures within chamber **14**. A high thermal conductivity for sleeve **54** is required in order to transport as much heat as possible through the tubular walls into the incoming stream of supply air. Thermal conductivity of silicon carbide in the chamber environment is seen to vary between 100–50 BTU/HR–FT²/° F. for chamber **14** temperature range between 800°–2400° F. respectively. In this way, supply air passing through conduit passage **40** and sleeve through opening **56** may be heated by as much as several hundred degrees before impinging on flame front **20**.

Nozzle end **58** of sleeve **54** provides a smaller diameter axial opening that is found in sleeve through opening **56**. The air supply as it is being heated upon passage through sleeve **54** has its velocity increased through the nozzle effect created by the throat of nozzle end **58**. The increased velocity of the inlet air in combination with the vortex motion created by angled vanes **52** provides for greater turbulance and agitation of the air supply in order to utilize a larger portion of the unburned gases and permit a larger heat source from flame front **20**.

Fuel combustion within combustion chamber **14** is dependent upon the chemical formula of the specific fuel and the amount of air inlet to aid in combustion. Fuels from different geographical locations vary somewhat in their constituency, however, a fuel having the formula C_8H_{18} is taken to show operation of system **10** as described. In standard furnaces **12**, a combustion process is found with atmospheric air and not with pure oxygen. Normally, the nitrogen and other gases in the air are merely dilutants of the incoming oxygen and appear in the products mainly unchanged in form. This may be seen from the well known combustion of carbon and oxygen:

$$C + O_2 \longrightarrow CO_2 \quad (1)$$

however, when the oxygen is now supplied to the combustion process by air, the combustion equation becomes:

$$C + O_2 + 3.76N_2 \longrightarrow CO_2 + 3.76N_2 \quad (2)$$

In the chemically balanced equation for combustion of the fuel having the formula C_8H_{18}, it is seen:

$$C_8H_{18} + 12.5O_2 + 46N_2 \longrightarrow 8CO_2 + 9H_2O + 47N_2 \quad (3)$$

Equation (3) provides for the chemically correct, stoichiometric or theoretical amount of air necessary for the process to convert the fuel into completely oxidized products. In present furnaces **12** the time of the fuel/air mixture is not sufficient in the combustion zone to break down their atomic bond. In order to aid in combusting the total amount of fuel, excess air may be incorporated to provide more oxygen. Assuming **25** percent excess air is supplied to the reaction as described in equation (3), it is seen:

$$C_8H_{18} + \frac{5}{4}(12.5)O_2 + \frac{5}{4}(47)N_2 \longrightarrow 8CO_2 + 9H_2O + 3.12O_2 + 58.75N_2 \quad (4)$$

The excess air appears in the products unchanged in form. In this manner, excess oxygen is provided to oxidize some of the fuel which was not initially combusted.

In the present invention, the step of providing excess oxygen to chamber **14** is taken further to enable cracking of still more of the unburned fuel and reduce pollutants while at the same time increasing fuel efficiency. Inlet air passing into chamber **14** opposes flame front **20**, thereby forcing the flame envelope back and producing an effective heat source having a smaller surface area of radiation. The heat radiated away from the flame envelope may be written:

$$Q_R = A\epsilon T^4 \quad (5)$$

where:

Q_R = Heat transport by radiation from flame envelope

= Stefan Boltzmann constant

A = Effective surface area of flame envelope

ϵ = Emissivity of flame envelope

T = Temperature of flame envelope

As can be seen in equation (5) as the effective surface area of the flame envelope is compressed, the temperature of the envelope must be increased for the same amount of radiant heat generation. Increasing the flame front **20** temperature therein provides more cracking capability with an associated increase in the amount of heat being transported. Vortexing of the inlet air through preheating sleeve **54** also forces some of the unused fuel back into flame front **20** to increase the heating capability of furnace **12**. The entire process is iterative wherein a lower flame envelope surface area causes a higher flame temperature which in turn causes a greater heat capability to burn more of the fuel.

The actual effect that is created by system **10** is to make an afterburner of the primary flame. More time is allowed for combustion of the fuel within the oxidizing zone thereby providing for a greater fuel consumption than was previously obtainable.

It will now be understood that the method for increasing fuel combustion efficiency within chamber **14** includes the introduction of inlet air into chamber **14** directed toward and impinging on flame front **20** being emitted from fuel burner **16**. Ambient air is inlet to fan **14** and is passed under high pressure through conduit **28** and introduced into chamber **14**. Inlet air flow is positioned in a streamline contour opposing flame front **20** in longitudinal direction **13**. At the entrance to chamber **14** the inlet air is vortexed upon passage through angled vanes **52** to produce a streamline air flow contour in transverse direction **15** to provide a flow combination motion. Once the inlet air is transported within chamber **14**, it is preheated by motion through a high thermally conductive sleeve **54** subsequent to chamber **14** introduction and prior to air inlet flow impingement on flame front **20**. In addition, the velocity of the inlet air is increased after preheating by nozzle end **58** of ceramic sleeve **54** to provide high velocity impingement on flame front **20**.

An embodiment of assembly **10** is shown in FIG. **5** where inlet air is drawn into furnace **12** through a pressure differential between internally heated air and the ambient external environment. As shown, ambient air enters partial passage **72** developed between inner furnace wall **74** and outer wall **76** through air inlet opening **60**. Inlet air flows through partial passage **72** into combustion chamber **14** through fuel burner inlet opening **62** and ceramic sleeve opening **64**. Damper door **66**, hinged to face plate **68**, is rotatable about a hinged axis. Ceramic sleeve opening **64** determines the amount of inlet air which will be preheated and vortexed into flame front **20**. Heater air within chamber **14** has a higher temperature than ambient external air and, therefore, will have a lower pressure to promote a continuous flow of external air through passage **72** into chamber **14**. Proper percentages of air flowing through fuel burner inlets **62** and ceramic sleeve opening **64** may be determined, and damper door **66** automatically adjusted to promote the most efficient burning of fuel within chamber **14**. Angled vanes **52** may be placed within face plate **68** or on side walls of ceramic sleeve **54** as shown in FIG. **7**. Inlet air flowing through ceramic sleeve **54** is vortexed through angled vanes **52** in a direction countercurrent to flame front **20**. Ceramic sleeve **54** extends longitudinally and in the same direction as fuel burner **16**, however, vortexing of inlet air provides for a compression of flame front **20** in a manner similar to the counter current flow described previously.

Another embodiment of the invention is shown in FIG. **6** where preheating sleeve **54** is spatially positioned similar to that shown in the embodiment described by FIG. **5**. Induced draft is formed in this embodiment by fan **24** which inputs air into chamber **14** under high pressure. Sleeve **54** located below fuel burner **16** in furnace side wall **18** extends longitudinally and in the same direction as flame front **20**. Air flowing longitudinally through preheating sleeve **54** is vortexed in a manner similar to that described for the embodiment of FIG. **5** and is driven into the flame front to compress and cause turbulent flow which increases heat transfer efficiency yielding a higher heat dissipation capability from flame front **20**.

In the invention as described, higher temperatures in the combusting zone are obtained by heating a predetermined proportional amount of secondary air within furnace **12**. The introduction of secondary air in the manner described produces more rapid and complete combustion within the flame envelope having a more uniform temperature throughout the combusting zone than was found in previous systems. Temperature gradients from a hot to cold zone within chamber **14** produce vast quantities of pollutants in the form of smoke and soot. In boiler applications a reduction in fuel consumption is found through the use of system **10** where a major proportion of radiant heat release is cap-

tured by steam generating tubes which may be exposed to the flame.

The shaping and directing of heated air in a vortexed and countercurrent manner reduces the requirement for high excess air to be maintained in order to provide a clean flame. The lower requirement for clean, efficient combustion with less excess air will result in a further reduction of heat losses and higher combustion efficiency. The forcing of air into chamber **14** with a controlled volume and velocity having a rotational direction into the main flame front concentrates the hydrocarbons in the highest temperature zone which assists in a high radiant heat release. Additional savings are realized in the reduction of soot, blowing requirements, cleaner tube surfaces, and maintenance of a maximum degree of convection gas heat transfer.

What is claimed:

1. A supplemental air supply assembly to increase fuel combustion efficiency within a combustion chamber having a fuel burner forming a flame envelope having a surface area with a longitudinal and a transverse direction comprising:

high pressure air inlet means extending through a wall of said combustion chamber for decreasing said surface area of said flame envelope thereby increasing the radiant heat transport to enclosing internal boundaries of said combustion chamber, said high pressure air having a direction substantially opposing said longitudinal direction of said flame envelope; and,

means for vortexing said high pressure air for encompassing said flame envelope surface area.

2. The assembly as recited in claim **1** wherein said vortexing means includes helical dispersion means to induce said streamline air flow helically about said longitudinal dimension of said flame envelope.

3. The assembly as recited in claim **1** wherein said air inlet means is positioned within said wall of said combustion chamber longitudinally opposing said flame envelope.

4. The assembly as recited in claim **1** wherein said air inlet means includes means for providing air flow pressure internal to said combustion chamber in excess of said ambient air pressure.

5. The assembly as recited in claim **1** wherein said air inlet means includes:

blower means external to said combustion chamber for producing a high pressure air flow; and,

conduit means coupled to said blower means and said wall of said combustion chamber to direct a predetermined quantity of said high pressure air into said combustion chamber.

6. The assembly as recited in claim **5** wherein there is provided a damping device for controllably restricting the internal passage of said conduit means to regulate the amount of high pressure air flowing through said conduit means.

7. The assembly as recited in claim **5** wherein said conduit means includes:

a. damping motor means;

b. an air flow blocking panel angularly oriented with respect to said conduit means passage to restrict the cross-sectional area of said passage responsive to said damping motor means actuation; and,

c. a temperature sensing element connected on opposing ends to said damping motor means and internal to said combustion chamber respectively, said temperature sensing element to measure said air flow temperature within said chamber and actuate said damping motor means.

8. The assembly as recited in claim **5** wherein said conduit means is secured to said combustion chamber wall longitudinally opposed to said flame envelope to produce said air flow in a direction countercurrent to said longitudinal dimension.

9. The assembly as recited in claim **5** wherein said conduit means includes a plurality of angled vanes secured to an inner diameter of said conduit means to direct said air flow in a transverse direction with respect to said longitudinal dimension of said flame envelope.

10. The assembly as recited in claim **9** includes an elbow section to transform initially directed air flow from said blower means to a longitudinal flow within said combustion chamber.

11. The assembly as recited in claim **10** wherein said elbow sectional element includes a tube extending in said longitudinal dimension, said tube being fixedly secured central to said passage of said conduit means and passing external thereto through a wall of said elbow sectional element, said tubing having a central through opening sealed with a high temperature transparent material external to said elbow sectional element for visual observation internal to said combustion chamber.

12. The assembly as recited in claim **9** wherein said tube includes a plurality of formed vanes secured to the periphery of said tube within said passage of said conduit means to direct the flow of said air helically about said longitudinal dimension of said flame envelope.

13. The assembly as recited in claim **1** including preheating air means rigidly secured to said air inlet means extending within said combustion chamber in said longitudinal dimension directed toward said flame envelope to heat said inlet air within said combustion chamber prior to entry into said flame envelope.

14. The assembly as recited in claim **13** wherein said preheating air means includes a tubular sleeve having a through opening, said sleeve being coaxially displaced with respect to said air inlet means.

15. The assembly as recited in claim **14** wherein said sleeve includes a first end fastened to said air inlet means and a second end having a decreased nozzle opening to increase the velocity of said air flow.

16. The assembly as recited in claim **14** wherein said sleeve is constructed of a high thermally conductive material to permit transport of heat from said combustion chamber to said air flowing therethrough.

17. The assembly as recited in claim **14** wherein said preheating air sleeve is constructed of silicon carbide.

18. The assembly as recited in claim **14** wherein said preheating air sleeve includes a plurality of helically extended air flow vanes secured to an internal diameter thereof to direct said air flow in a transverse direction with respect to said longitudinal dimension of said flame envelope.

19. The method of increasing radiant heat transport from a flame envelope contained within a combustion chamber having a fuel burner, said flame envelope

$$C_8H_{18} + 12.5O_2 + 46N_2 \longrightarrow 8CO_2 + 9H_2O + 47N_2 \quad (3)$$

Equation (3) provides for the chemically correct, stoichiometric or theoretical amount of air necessary for the process to convert the fuel into completely oxidized products. In present furnaces **12** the time of the fuel/air mixture is not sufficient in the combustion zone to break down their atomic bond. In order to aid in combusting the total amount of fuel, excess air may be incorporated to provide more oxygen. Assuming **25** percent excess air is supplied to the reaction as described in equation (3), it is seen:

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The excess air appears in the products unchanged in form. In this manner, excess oxygen is provided to oxidize some of the fuel which was not initially combusted.

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where:

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The actual effect that is created by system **10** is to make an afterburner of the primary flame. More time is allowed for combustion of the fuel within the oxidizing zone thereby providing for a greater fuel consumption than was previously obtainable.

It will now be understood that the method for increasing fuel combustion efficiency within chamber **14** includes the introduction of inlet air into chamber **14** directed toward and impinging on flame front **20** being emitted from fuel burner **16**. Ambient air is inlet to fan **14** and is passed under high pressure through conduit **28** and introduced into chamber **14**. Inlet air flow is positioned in a streamline contour opposing flame front **20** in longitudinal direction **13**. At the entrance to chamber **14** the inlet air is vortexed upon passage through angled vanes **52** to produce a streamline air flow contour in transverse direction **15** to provide a flow combination motion. Once the inlet air is transported within chamber **14**, it is preheated by motion through a high thermally conductive sleeve **54** subsequent to chamber **14** introduction and prior to air inlet flow impingement on flame front **20**. In addition, the velocity of the inlet air is increased after preheating by nozzle end **58** of ceramic sleeve **54** to provide high velocity impingement on flame front **20**.

An embodiment of assembly **10** is shown in FIG. **5** where inlet air is drawn into furnace **12** through a pressure differential between internally heated air and the ambient external environment. As shown, ambient air enters partial passage **72** developed between inner furnace wall **74** and outer wall **76** through air inlet opening **60**. Inlet air flows through partial passage **72** into combustion chamber **14** through fuel burner inlet opening **62** and ceramic sleeve opening **64**. Damper door **66**, hinged to face plate **68**, is rotatable about a hinged axis. Ceramic sleeve opening **64** determines the amount of inlet air which will be preheated and vortexed into flame front **20**. Heater air within chamber **14** has a higher temperature than ambient external air and, therefore, will have a lower pressure to promote a continuous flow of external air through passage **72** into chamber **14**. Proper percentages of air flowing through fuel burner inlets **62** and ceramic sleeve opening **64** may be determined, and damper door **66** automatically adjusted to promote the most efficient burning of fuel within chamber **14**. Angled vanes **52** may be placed within face plate **68** or on side walls of ceramic sleeve **54** as shown in FIG. **7**. Inlet air flowing through ceramic sleeve **54** is vortexed through angled vanes **52** in a direction countercurrent to flame front **20**. Ceramic sleeve **54** extends longitudinally and in the same direction as fuel burner **16**, however, vortexing of inlet air provides for a compression of flame front **20** in a manner similar to the counter current flow described previously.

Another embodiment of the invention is shown in FIG. **6** where preheating sleeve **54** is spatially positioned similar to that shown in the embodiment described by FIG. **5**. Induced draft is formed in this embodiment by fan **24** which inputs air into chamber **14** under high pressure. Sleeve **54** located below fuel burner **16** in furnace side wall **18** extends longitudinally and in the same direction as flame front **20**. Air flowing longitudinally through preheating sleeve **54** is vortexed in a manner similar to that described for the embodiment of FIG. **5** and is driven into the flame front to compress and cause turbulent flow which increases heat transfer efficiency yielding a higher heat dissipation capability from flame front **20**.

In the invention as described, higher temperatures in the combusting zone are obtained by heating a predetermined proportional amount of secondary air within furnace **12**. The introduction of secondary air in the manner described produces more rapid and complete combustion within the flame envelope having a more uniform temperature throughout the combusting zone than was found in previous systems. Temperature gradients from a hot to cold zone within chamber **14** produce vast quantities of pollutants in the form of smoke and soot. In boiler applications a reduction in fuel consumption is found through the use of system **10** where a major proportion of radiant heat release is cap-

tured by steam generating tubes which may be exposed to the flame.

The shaping and directing of heated air in a vortexed and countercurrent manner reduces the requirement for high excess air to be maintained in order to provide a clean flame. The lower requirement for clean, efficient combustion with less excess air will result in a further reduction of heat losses and higher combustion efficiency. The forcing of air into chamber **14** with a controlled volume and velocity having a rotational direction into the main flame front concentrates the hydrocarbons in the highest temperature zone which assists in a high radiant heat release. Additional savings are realized in the reduction of soot, blowing requirements, cleaner tube surfaces, and maintenance of a maximum degree of convection gas heat transfer.

What is claimed is:

1. A supplemental air supply assembly to increase fuel combustion efficiency within a combustion chamber having a fuel burner forming a flame envelope having a surface area with a longitudinal and a transverse direction comprising:

high pressure air inlet means extending through a wall of said combustion chamber for decreasing said surface area of said flame envelope thereby increasing the radiant heat transport to enclosing internal boundaries of said combustion chamber, said high pressure air having a direction substantially opposing said longitudinal direction of said flame envelope; and,

means for vortexing said high pressure air for encompassing said flame envelope surface area.

2. The assembly as recited in claim **1** wherein said vortexing means includes helical dispersion means to induce said streamline air flow helically about said longitudinal dimension of said flame envelope.

3. The assembly as recited in claim **1** wherein said air inlet means is positioned within said wall of said combustion chamber longitudinally opposing said flame envelope.

4. The assembly as recited in claim **1** wherein said air inlet means includes means for providing air flow pressure internal to said combustion chamber in excess of said ambient air pressure.

5. The assembly as recited in claim **1** wherein said air inlet means includes:

blower means external to said combustion chamber for producing a high pressure air flow; and,

conduit means coupled to said blower means and said wall of said combustion chamber to direct a predetermined quantity of said high pressure air into said combustion chamber.

6. The assembly as recited in claim **5** wherein there is provided a damping device for controllably restricting the internal passage of said conduit means to regulate the amount of high pressure air flowing through said conduit means.

7. The assembly as recited in claim **5** wherein said conduit means includes:

a. damping motor means;

b. an air flow blocking panel angularly oriented with respect to said conduit means passage to restrict the cross-sectional area of said passage responsive to said damping motor means actuation; and,

c. a temperature sensing element connected on opposing ends to said damping motor means and internal to said combustion chamber respectively, said temperature sensing element to measure said air flow temperature within said chamber and actuate said damping motor means.

8. The assembly as recited in claim **5** wherein said conduit means is secured to said combustion chamber wall longitudinally opposed to said flame envelope to produce said air flow in a direction countercurrent to said longitudinal dimension.

9. The assembly as recited in claim **5** wherein said conduit means includes a plurality of angled vanes secured to an inner diameter of said conduit means to direct said air flow in a transverse direction with respect to said longitudinal dimension of said flame envelope.

10. The assembly as recited in claim **9** includes an elbow section to transform initially directed air flow from said blower means to a longitudinal flow within said combustion chamber.

11. The assembly as recited in claim **10** wherein said elbow sectional element includes a tube extending in said longitudinal dimension, said tube being fixedly secured central to said passage of said conduit means and passing external thereto through a wall of said elbow sectional element, said tubing having a central through opening sealed with a high temperature transparent material external to said elbow sectional element for visual observation internal to said combustion chamber.

12. The assembly as recited in claim **9** wherein said tube includes a plurality of formed vanes secured to the periphery of said tube within said passage of said conduit means to direct the flow of said air helically about said longitudinal dimension of said flame envelope.

13. The assembly as recited in claim **1** including preheating air means rigidly secured to said air inlet means extending within said combustion chamber in said longitudinal dimension directed toward said flame envelope to heat said inlet air within said combustion chamber prior to entry into said flame envelope.

14. The assembly as recited in claim **13** wherein said preheating air means includes a tubular sleeve having a through opening, said sleeve being coaxially displaced with respect to said air inlet means.

15. The assembly as recited in claim **14** wherein said sleeve includes a first end fastened to said air inlet means and a second end having a decreased nozzle opening to increase the velocity of said air flow.

16. The assembly as recited in claim **14** wherein said sleeve is constructed of a high thermally conductive material to permit transport of heat from said combustion chamber to said air flowing therethrough.

17. The assembly as recited in claim **14** wherein said preheating air sleeve is constructed of silicon carbide.

18. The assembly as recited in claim **14** wherein said preheating air sleeve includes a plurality of helically extended air flow vanes secured to an internal diameter thereof to direct said air flow in a transverse direction with respect to said longitudinal dimension of said flame envelope.

19. The method of increasing radiant heat transport from a flame envelope contained within a combustion chamber having a fuel burner, said flame envelope

defining a surface area having a longitudinal and transverse direction, said flame envelope surface area to be decreased, including the steps of

a. positioning a high pressure inlet air flow in a streamline contour substantially opposing in direction said flame envelope longitudinal direction; and

b. vortexing said high pressure inlet air flow to produce a streamline air flow contour in said transverse direction of said flame envelope.

20. The method as recited in claim **19** including the step of:

preheating said high pressure inlet air within said combustion chamber subsequent to said introduction and prior to said impingement of said high pressure inlet air on said flame envelope, said preheating for raising the temperature of said high pressure inlet air thereby increasing the fuel combustion efficiency.

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