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(54) Biomass center air jet burner

(57) A combustion apparatus capable of firing biomass fuel including a burner assembly which includes a biomass nozzle (18) concentrically surrounded by a core air zone (8) and extending axially along the length of the core air zone, the burner assembly residing within a windbox (2), the windbox being attached to a furnace (3) of a boiler, and the burner assembly being connected to the furnace by a burner throat (4), through which air and fuel supplied to the burner assembly are emitted into the furnace.

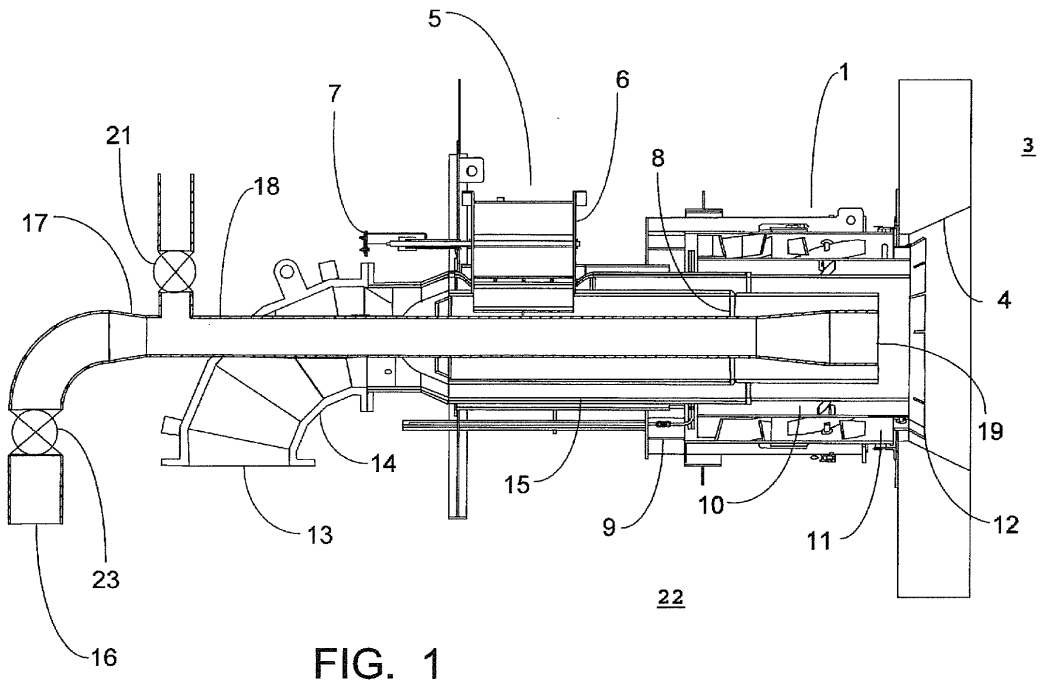


FIG. 1

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Description

FIELD

[0001] The present invention relates generally to the field of industrial burner apparatuses for performing combustion functions for power generation.

[0002] As used herein the term "biomass" describes a wide range of organic matter derived from diverse living, or recently-living organisms, such as grasses and wood products. Sources of biomass include trees, shrubs, bushes, residual vegetation from harvesting grains and vegetables. Biomass is commonly plant matter harvested to generate electricity or produce heat. Biomass may also include biodegradable wastes of organic origin that can be burned as fuel.

[0003] Biomass differs from fossil fuels, which are hydrocarbons found within the top layer of the Earth's crust. Common examples of fossil fuels include coal and oil. Unlike fossil fuels, biomass fuels are generally considered CO_2 neutral and renewable resources, since CO_2 generated from biomass combustion can be removed from the atmosphere by the plants that provide the biomass.

[0004] As the physical properties and chemical composition of biomass differ greatly from that of coal, biomass fuels for power generation have historically been utilized as a primary or auxiliary fuel in stoker and fluid bed style boilers. Such boilers do not rely on burners thereby enabling significantly higher furnace residence time for combustion and consequently have less stringent fuel preparation requirements.

[0005] Global warming concerns relating to greenhouse gas emissions has increased the interest in developing new technologies to enable widespread use of renewable resources for power generation. One area of such interest is the use of biomass fuels in suspension firing, wherein short furnace residence times require fine particles for efficient combustion.

[0006] Pulverized coal firing is the primary means of suspension firing in the power generation industry. In a first step coal is mechanically pulverized into fine particles. The particles are then subsequently conveyed via suspension in a primary air stream to a burner, wherein the burner ejects the air/fuel mixture in a furnace for combustion. Residence times are nominally 1 to 2 seconds, which is normally sufficient for complete pulverized coal combustion with proper particle sizing.

[0007] Biomass firing in pulverized coal-fired boilers is becoming more widespread as a strategy for reducing greenhouse gases. To enable this strategy a need exists to develop a burner capable of effectively utilizing biomass fuels in suspension firing.

[0008] Firing biomass fuels faces many technical challenges. As compared to bituminous coal, biomass fuels have significantly lower heating values and a higher concentration of volatile matter. Heating value is inversely proportional to moisture content, such that it amounts to 25% to 75% that of a typical bituminous coal. Biomass moisture will often be reduced prior to firing for material handling reasons and to improve process efficiency and capacity. Nevertheless, firing biomass in place of coal requires considerably more fuel mass to achieve a comparable heat output. Further, while the highly-volatile nature of biomass makes the fuel inherently easy to burn, the high moisture content can delay ignition. Delayed ignition is especially undesirable in suspension firing,

[0009] Another concern with biomass fuels is that biomass is not processed to the same particle size as pulverized coal. Experience indicates successful suspension firing can be achieved with wood particles sized 0.0625 in. compared to the top size for pulverized coal of 0.012 in. Particle volume varies by the diameter cubed, thus wood particles have approximately 150 times the volume of larger coal particles used for suspension firing. The larger volume of the biomass thus requires quick ignition and rapid combustion to enable use of biomass in furnaces designed for pulverized coal firing.

[0010] One known technique of utilizing biomass in suspension firing is biomass co-firing. In this technique biomass particulate is combined with pulverized coal and primary air in a single stream. The combined stream is then introduced into the furnace. This technique is however limited in practicality due to the resulting burner nozzle velocity necessary to maintain both types of particles in suspension. Excessive burner nozzle velocity results in flame instability, delayed ignition, and poor combustion performance.

[0011] Thus, there remains a need to develop a means for an efficient and effective alternative to combusting coal for power generation and a means for enabling the widespread combustion of a carbon-neutral fuel for power generation applications.

[0012] US Patent 7,430,970 to LaRue et al. ('970 patent), is hereby incorporated into by reference in its entirety.

SUMMARY

[0013] Viewed from one aspect, there can be provided a combustion apparatus capable of firing biomass fuel and alternating between biomass and coal firing, as needed, and/or combusting a combination of coal and biomass fuels concurrently.

[0014] Viewed from another aspect, there can be provided a device for combusting renewable fuels, including, but not limited to, biomass.

[0015] Viewed from a further aspect, there can be provided a method and apparatus for co-firing biomass in combination with pulverized coal.

[0016] According to one aspect, there can be provided a combustion apparatus capable of firing biomass fuel including a burner assembly which includes a biomass nozzle concentrically surrounded by a core air zone and extending axially along the length of the core air zone, the burner assembly residing within a windbox, the wind-

box being attached to a furnace of a boiler, and the burner assembly being connected to the furnace by a burner throat, through which air and fuel supplied to the burner assembly are emitted into the furnace.

[0017] In various embodiments, the apparatus can include some or all of a forced draft fan providing a first supply of air to the windbox, a core air duct, enclosing the core air zone, for receiving a core portion of the first supply of air, the core air duct having a core damper for regulating the core portion entering the core air duct, a core nozzle for receiving the core portion from said core air duct, the core nozzle delivering said core portion to said burner throat, a burner elbow for receiving pulverized coal and a second supply of air, the pulverized coal and said second supply of air continuing through a coal nozzle in an annulus formed between the core nozzle and the coal nozzle, the core portion serving to accelerate ignition of pulverized coal by contacting an inner cylinder of a coal jet leaving the coal nozzle, the core portion also serving to accelerate combustion.

[0018] Further aspects and embodiments will become apparent from the detailed description and accompanying Figures, and from the appended claims.

BRIEF DESCRIPTION OF THE DRAWINGS

[0019] In the drawings:

[0020] Fig 1. is a schematic side elevation view of an apparatus;

[0021] Fig 2. is a schematic side elevation view of an alternative apparatus;

[0022] Fig 3. is a schematic side elevation view of another alternative apparatus;

[0023] Fig 4. is a schematic cross sectional view of an apparatus showing concentric zones.

[0024] While the invention is susceptible to various modifications and alternative forms, specific embodiments are shown by way of example in the drawings and are herein described in detail. It should be understood, however, that drawings and detailed description thereto are not intended to limit the invention to the particular form disclosed, but on the contrary, the invention is to cover all modifications, equivalents and alternatives falling within the spirit and scope of the present invention as defined by the appended claims.

DETAILED DESCRIPTION

[0025] With reference to the figures, wherein like references designate the same or functionally similar elements throughout the several drawings, a number of example arrangements will now be described.

[0026] Fig. 1 shows a burner assembly 1 residing within windbox 2, which is attached to the furnace 3 of a boiler (not shown). Secondary air 22 is provided to windbox 2 by a forced draft fan (not shown) and heated by an air preheater (not shown). The burner assembly 1 is connected to furnace 3 by burner throat 4, through which air and fuel supplied to the burner assembly 1 are emitted into the furnace 3. A portion of the secondary air 22 constitutes core air 5. Core air 5 enters core air duct 6 and is regulated by core air damper 7. Core air 5 continues through the burner assembly 1 through core nozzle 8, exiting through the burner throat 4.

[0027] Secondary air 22 is also supplied to the burner assembly (designated as secondary air to the burner assembly 9). Secondary air 22 enters the burner assembly 1 and travels through parallel flow paths of the inner air zone 10 and outer air zone 11. Swirl vanes in these zones serve to swirl secondary air 22 to facilitate ignition and combustion of secondary air 22 contacting the pulverized coal stream. An air separation vane 12 at the exit of outer zone 11 acts to increase the size of an internal recirculation zone (IRZ) formed by resultant aerodynamics. Pulverized coal and primary air 13 enter burner elbow 14 and continue through coal nozzle 15, in the annulus formed between core nozzle 8 and coal nozzle 15. The core air 5 serves to accelerate ignition of pulverized coal by contacting the inner cylinder of the coal jet (not shown) leaving the coal nozzle 15; and serves to accelerate combustion by a "bellows effect" supplying air to the center of the flame. LaRue '970 provides a detailed discussion on the accelerated ignition relating to core air.

[0028] The burner assembly 1 according to the present embodiment may be operated in combination with an over-fire-air ("OFA") system (not shown). A portion of the secondary air 22 supplied to the furnace for combustion is supplied to the OFA system, such that the total amount of air supplied to the burner assembly 1 is less than theoretical air requirements. This produces a reducing environment in the furnace before OFA is supplied. The accelerated combustion, higher temperature flame, and larger IRZ all serve to more effectively reduce NO_x under reducing conditions.

[0029] In some embodiment, biomass may be prepared for suspension firing using shredders, hammer mills and the like (not shown), collected and regulated in feed rate by a screw feeder or equivalent device (not shown) and pneumatically conveyed to the burner assembly 1 through an appropriate conduit. The conduit supplies biomass and transport air 16 through an elbow 14 whose outlet is situated at the axis of the burner 1.

[0030] In some embodiments, a reducer 17 may be used to reduce the cross-sectional area of biomass nozzle 18 as the nozzle transverses the burner elbow 14 and continues past the core air duct 16. A reducer 17 serves to lessen the flow obstruction as the biomass nozzle 18 extends through the length of the burner assembly 1. Near the furnace end of the burner assembly 1, the biomass nozzle tip 19 diameter can be expanded as shown (Fig 1.) to reduce the biomass exit velocity to the optimum value for combustion. In certain embodiments, this exit velocity is between about 2500 ft/min and about 5000 ft/min, and in further embodiments is between about 3000 ft/min and 4000 ft/min.

[0031] In further embodiments, core air 5 surrounding

the biomass nozzle tip 19 serves to accelerate ignition of the biomass as it enters the burner throat 4, and supplies air to feed combustion as the biomass continues into the furnace. The hot secondary core air that surrounds the biomass nozzle provides heat to enable additional moisture removal from the biomass fuel while supplying the fuel with an oxidant to facilitate ignition and combustion. This contributes to avoiding delayed ignition and/or combustion of biomass. Core air damper 7 can be adjusted to supply core air 5 in such quantity so as to minimize NO_x emissions when firing biomass in combination with pulverized coal. For times when biomass is not being fired, the biomass supply system (not shown) serving the burner assembly 1 can be shut down and valve 23 closed. Valve 21 can then be opened and adjusted in combination with core damper 7 to supply the optimum amount of core air 5 necessary for minimizing NO_x when firing the particular coal. When the biomass is to be fired, valve 21 is shut and valve 23 is opened to admit biomass and transport air 16.

[0032] Referring now to Fig.4, a schematic cross section of the burner assembly 1 is shown wherein the five distinct zones of the burner assembly 1 are identified. A biomass zone 32 defined by biomass nozzle 18 is concentrically surround by a core air zone 44 defined the area between biomass nozzle 18 and core nozzle 8. A coal nozzle 15 concentrically surrounds core nozzle 8 defining a first annular zone 47 wherein pulverized coal and primary air (PC/PA) 13 flows. A barrel 42 concentrically surrounds coal nozzle 15 and defines the inner air zone 10 internal to barrel 42 and an outer air zone 11 external to barrel 42.

[0033] Thus there has now been described an example arrangement of a burner that can be controlled to fire solely pulverized coal or a pulverized coal and biomass mix. This arrangement uses multiple concentrically arranged zones to provide efficient combustion in dependence upon the fuel mix provided. Further alternative embodiments and arrangements may also fall within the scope of the present disclosure.

[0034] Such alternative arrangements can include a straight pipe without reducer 17, and/or without expansion at the furnace end of biomass nozzle 18.

[0035] In the embodiment of Fig 2, an alternative approach of a shorter or recessed biomass nozzle 18 is shown. In this arrangement the biomass nozzle tip 19 terminates within the core nozzle 8 near the core air duct 6. This embodiment provides for preheating and premixing the biomass with the core air, thereby further enabling additional moisture removal from the biomass fuel.

[0036] In addition, or alternatively, a reducing taper may be used at the exit of the biomass nozzle 18 as shown in Fig 3. This provides acceleration of the biomass fuel as it enters the furnace 3 which can reduce the risk of flashback into the biomass nozzle 18.

[0037] While the biomass nozzle 18 is illustrated as an open-ended nozzle in the figures, it may be fitted with deflectors or swirlers near the exit to increase mixing rate of biomass with core air.

[0038] In other embodiments, adjustment means may be included to facilitate minor fore/aft adjustments in the end position of the biomass nozzle 18 relative to the core pipe to enable further optimization of combustion. While the biomass nozzle 18 is shown flush with the end of the core pipe in Figure 1, it may also be positioned slightly further back or further forward. In certain embodiments, valve 21 may be used to admit a small amount of air, either hot secondary air or unheated air, to add air to the center of the flame while firing biomass. This can augment center stoichiometry for reducing NO_x generation (as alternative to increasing transport air quantity).

[0039] Certain embodiments of the disclosed concepts can provide beneficial performance for firing of biomass fuels.

[0040] The large core zone provided in the burner arrangements discussed above can accommodates a biomass nozzle without changing the overall burner size. This can save the engineering and manufacturing costs associated with building burners of different sizes to accommodate biomass firing.

[0041] The large biomass nozzle provided in the burner arrangements described above can enable firing larger quantities of biomass in selected burners, such that fewer burners need be supplied to fire biomass. For example, biomass firing rates up to 40% of rated burner input enable boiler biomass firing rates of 20% while using only half the number of installed burners.

[0042] Furthermore, biomass fuel availability can vary over different times of the year such that biomass firing may not always be conducted continuously. In one alternative embodiment the biomass nozzle can be supplied with secondary air when not firing biomass such that both the biomass nozzle 18 and core nozzle 8 provide a combined core air jet for the combustion of pulverized coal.

[0043] Also, the transport air with biomass can contribute to a target or preferred center stoichiometry of the burner when firing biomass in combination with coal. In such case, the coal flow can be reduced such that a higher PA/PC ratio is supplied to the burner. This can augmented with transport air from biomass to provide a center stoichiometry conducive to very low NO_x emissions.

[0044] Further, the locating of the biomass nozzle in the core zone can provide a source of hot secondary air for igniting and feeding combustion of the biomass fuel, thus preventing delayed ignition as well as feeding combustion of the co-fired biomass fuel.

[0045] Some aspects of the disclosed concepts are set out in the following numbered clauses.

1. A combustion apparatus capable of firing biomass fuel, comprising:

a burner assembly comprising a biomass nozzle concentrically surrounded by a core air zone and extending axially along a length of said core air zone, said burner assembly residing within a

windbox, said windbox being attached to a furnace of a boiler, said burner assembly being connected to said furnace by a burner throat, through which air and fuel supplied to the burner assembly are emitted into the furnace;

a forced draft fan providing a first supply of air to said windbox;

a core air duct, enclosing said core air zone, for receiving a core portion of said first supply of air, said core air duct having a core damper for regulating said core portion entering said core air duct;

a core nozzle for receiving said core portion from said core air duct, said core nozzle delivering said core portion to said burner throat;

a burner elbow for receiving pulverized coal and a second supply of air; said pulverized coal and said second supply of air continuing through a coal nozzle, in an annulus formed between said core nozzle and said coal nozzle, said core portion serving to accelerate ignition of pulverized coal by contacting an inner cylinder of a coal jet leaving said coal nozzle; said core portion also serving to accelerate combustion.

2. The combustion apparatus according to clause 1, wherein said burner assembly is operated in combination with an over-fire-air system.

3. The combustion apparatus according to clause 1 or 2, further comprising a reducer for reducing the cross-sectional area of said biomass nozzle.

4. The combustion apparatus according to clause 1, 2 or 3, further comprising a reducing taper affixed to an exit of said biomass nozzle to accelerate the biomass fuel as said biomass fuel enters said furnace to prevent flashback into said biomass nozzle.

5. The combustion apparatus according to any preceding clause, further comprising at least one deflector near an exit of said biomass nozzle for increasing mixing rates of said biomass fuel with said core portion.

6. The combustion apparatus according to any preceding clause, further comprising at least one swirler near an exit of said biomass nozzle for increasing mixing rates of biomass fuel with said core portion.

7. The combustion apparatus according to any preceding clause, wherein said first supply of air is heated by an air preheater.

8. A method of operating the combustion apparatus according to any preceding clause, comprising providing a first valve and a second valve, wherein when biomass is not being supplied, said first valve is closed and said second valve is opened and adjusted in combination with said core damper to supply a desired amount of said core portion, and when biomass is supplied, said second valve is shut and said first valve is opened to admit biomass and transport air.

9. A biomass center air jet burner comprising a biomass pipe defining a biomass zone therein, an axial pipe concentrically surrounding the biomass pipe and defining an axial zone there between, an annular pipe concentrically surrounding the axial pipe defining a first annular zone there between, a barrel concentrically surrounding the annular pipe defining a second annular zone there between, a burner zone wall concentrically surrounding the barrel defining a third annular zone there between, a core air duct radially interposed between the axial pipe and the annular pipe, wherein the core air duct provides fluid communication between the axial zone and a windbox, and a means for conditioning a pulverized coal flow around a portion of the feeder duct contained in the first annular zone.

10. A burner as recited in clause 9, wherein the biomass pipe has a biomass nozzle tip that terminates within the axial pipe and prior to the core air duct.

11. A burner as recited in clause 9 or 10, wherein the biomass pipe has a biomass nozzle tip that terminates within a burner assembly and downstream of the core air duct.

12. A burner as recited in clause 9, 10 or 11 wherein the biomass nozzle tip radially expands within the burner assembly.

13. A burner assembly as recited in clause 9, 10, or 11 wherein the biomass nozzle tip radially reduces within the burner assembly.

14. A burner assembly as recited in any of clauses 9 to 13, wherein the biomass pipe further comprises of a flow valve.

15. A burner assembly as recited in any of clauses 9 to 14 wherein the biomass nozzle is longitudinally adjustable along the length of the burner assembly.

16. A burner assembly as recited in any of clauses 9 to 15, wherein the first annular zone contains a flow conditioning device.

17. A burner as recited in any of clauses 9 to 16,

wherein the biomass pipe further comprises a reducer downstream of the flow valve.

18. A burner as recited in any of clauses 9 to 17, further comprising a means for providing the first annular zone with a pulverized coal and a separate means from providing the biomass pipe with a biomass fuel.

19. A burner as recited in clause 18, further comprising a vane in the second annular zone, a vane in the third annular zone, and wherein the second annular zone and the third annular zone are in fluid communication with the windbox.

[0046] While illustrative embodiments have been shown and described in detail, it will be understood that the invention may be embodied otherwise without departing from such principles.

Claims

1. A biomass center air jet burner comprising:

a biomass nozzle concentrically surrounded by a core air zone and extending axially along the length of the core air zone,
wherein the burner is configured to receive air and fuel and to emit to a connected furnace via a burner throat.

2. The burner of claim 1, further comprising:

a biomass pipe leading to the biomass nozzle and defining a biomass zone;
an axial pipe concentrically surrounding the biomass pipe and defining the core air zone therebetween;
an annular pipe concentrically surrounding the axial pipe defining a first annular zone therebetween;
a barrel concentrically surrounding the annular pipe defining a second annular zone therebetween;
a burner zone wall concentrically surrounding the barrel defining a third annular zone therebetween;
a core air duct radially interposed between the axial pipe and the annular pipe, wherein the core air duct provides fluid communication between the axial zone and a windbox; and
a means for conditioning a pulverized coal flow around a portion of the feeder duct contained in the first annular zone.

3. A burner as recited in claim 2 wherein the tip of the biomass nozzle terminates within the axial pipe and prior to the core air duct.

4. A burner as recited in claim 2 wherein the tip of the biomass nozzle terminates within a burner assembly and downstream of the core air duct.

5. A burner as recited in any of claim 2, 3 or 4, wherein the biomass nozzle tip radially expands or reduces within the burner assembly.

6. A burner assembly as recited in any of claims 2 to 5, wherein the biomass pipe further comprises of a flow valve.

7. A burner assembly as recited in any of claims 2 to 6 wherein the biomass nozzle is longitudinally adjustable along the length of the burner assembly.

8. A burner assembly as recited in any of claims 2 to 7, wherein the first annular zone contains a flow conditioning device.

9. A burner as recited in any of claims 2 to 8, wherein the biomass pipe further comprises a reducer downstream of the flow valve.

10. A burner as recited in any of claims 2 to 9, further comprising a means for providing the first annular zone with a pulverized coal and a separate means for providing the biomass pipe with a biomass fuel.

11. A burner as recited in any of claims 2 to 10, further comprising a vane in the second annular zone, a vane in the third annular zone, and wherein the second annular zone and the third annular zone are in fluid communication with the windbox.

12. A combustion apparatus operable to fire biomass fuel, the apparatus comprising a burner according to any preceding claim, the burner assembly residing within a windbox, the windbox being configured to be attached to a furnace of a boiler, and the burner assembly being configured to be connected to the furnace by a burner throat, through which air and fuel supplied to the burner assembly are emitted into the furnace.

13. The combustion apparatus of claim 12, further comprising:

a forced draft fan providing a first supply of air to said windbox;
a core air duct, enclosing said core air zone, for receiving a core portion of said first supply of air, said core air duct having a core damper for regulating said core portion entering said core air duct;
a core nozzle for receiving said core portion from

said core air duct, said core nozzle delivering said core portion to said burner throat;
a burner elbow for receiving pulverized coal and a second supply of air; said pulverized coal and said second supply of air continuing through a coal nozzle, in an annulus formed between said core nozzle and said coal nozzle, said core portion serving to accelerate ignition of pulverized coal by contacting an inner cylinder of a coal jet leaving said coal nozzle; said core portion also serving to accelerate combustion.

14. The combustion apparatus according to claim 13, wherein said burner assembly is operated in combination with an over-fire-air system.

15. The combustion apparatus according to claim 13 or 14, further comprising a reducer for reducing the cross-sectional area of said biomass nozzle and/or a reducing taper affixed to an exit of said biomass nozzle.

16. The combustion apparatus according to any of claims 13 to 15, further comprising at least one deflector and/or swirler near an exit of said biomass nozzle for increasing mixing rates of said biomass fuel with said core portion and/or

17. The combustion apparatus according to any of claims 13 to 16, wherein said first supply of air is heated by an air preheater.

18. A method of operating the combustion apparatus according to any of claims 13 to 18, comprising providing a first valve and a second valve, wherein when biomass is not being supplied, said first valve is closed and said second valve is opened and adjusted in combination with said core damper to supply a desired amount of said core portion, and when biomass is supplied, said second valve is shut and said first valve is opened to admit biomass and transport air.

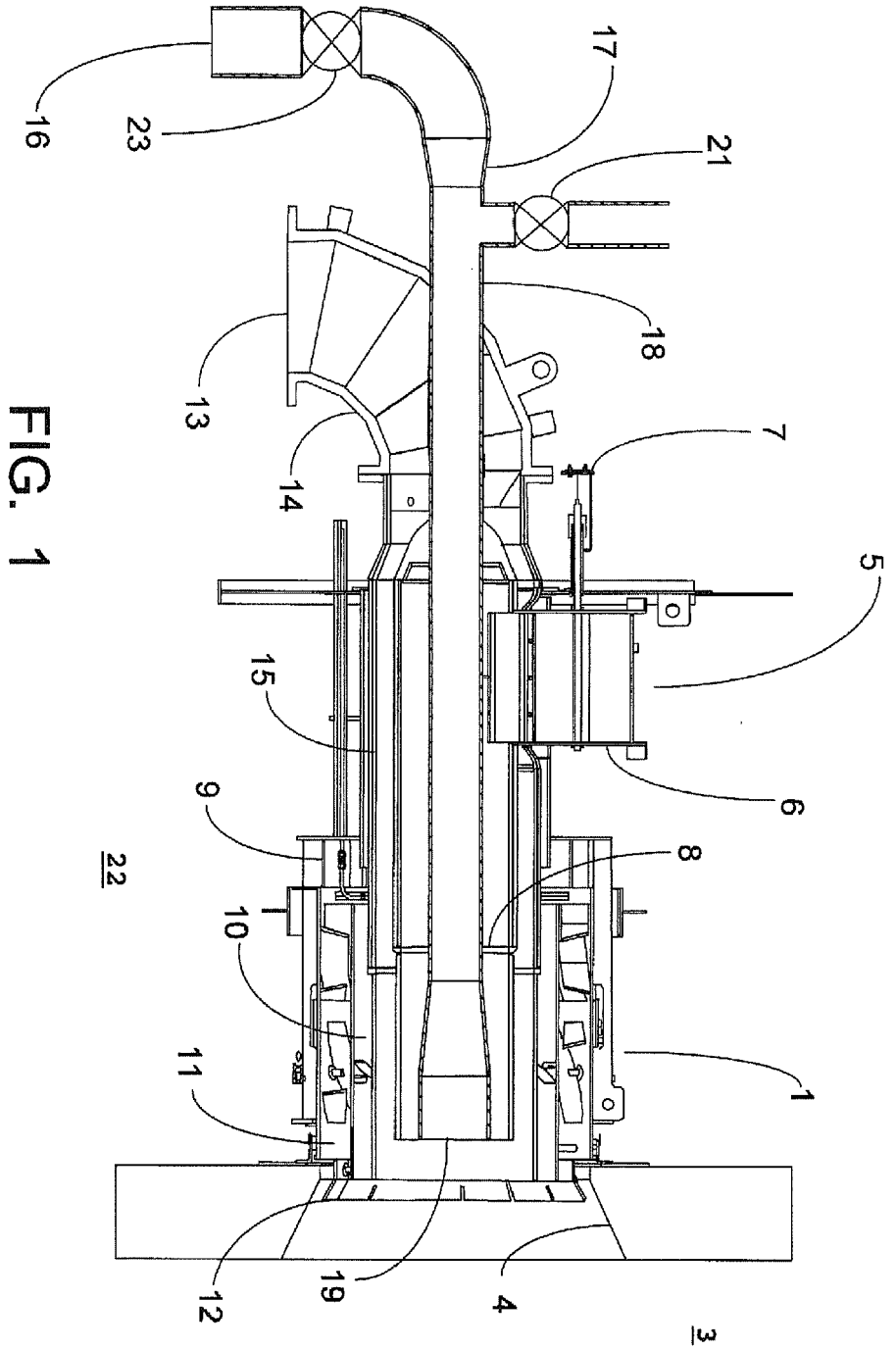


FIG. 1

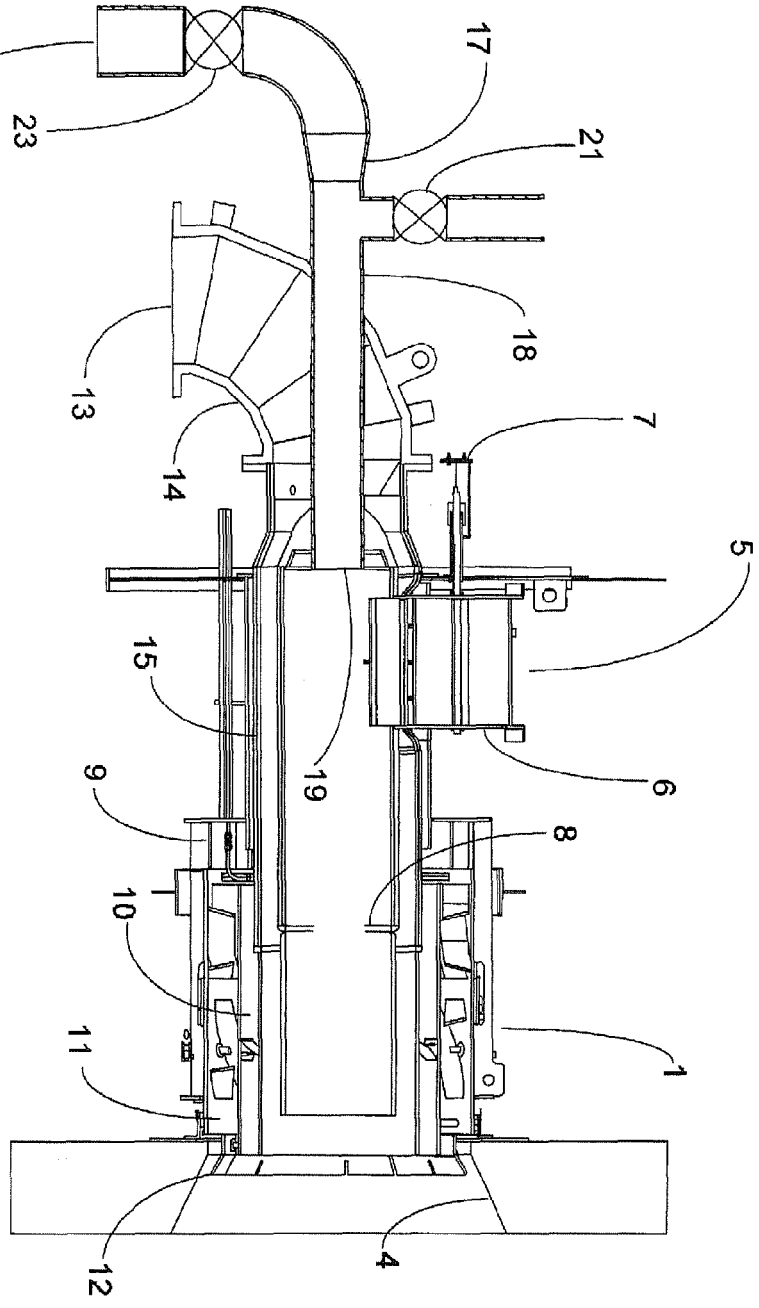


FIG. 2

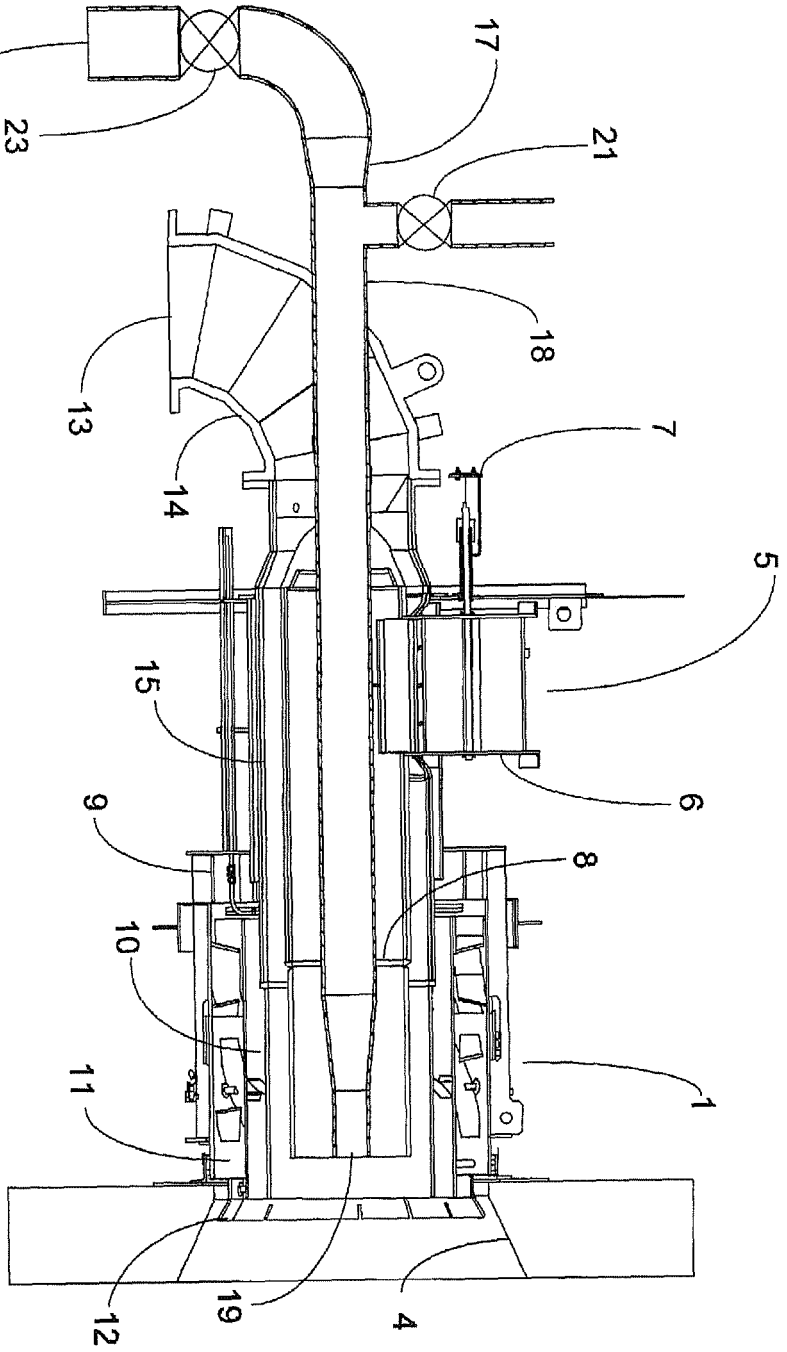


FIG. 3

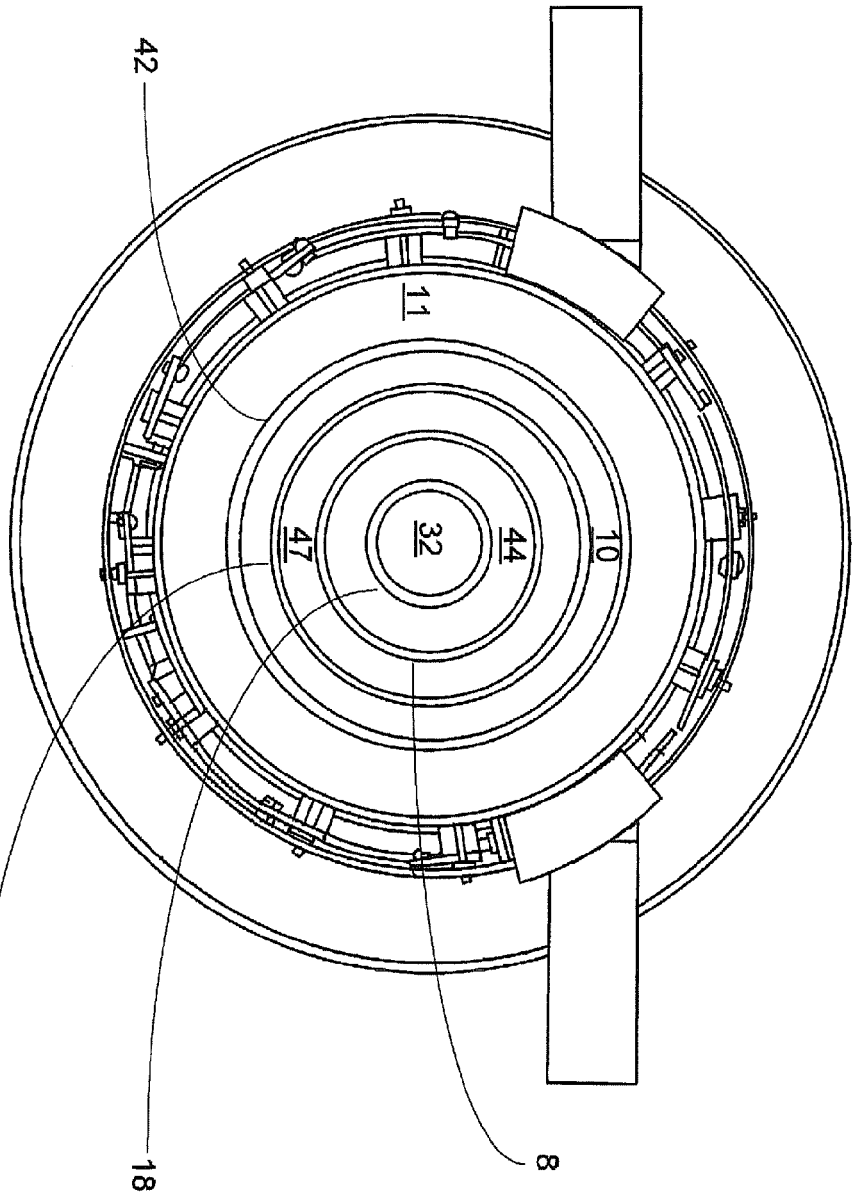


FIG. 4

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EUROPEAN SEARCH REPORT

Application Number
EP 10 16 1503

DOCUMENTS CONSIDERED TO BE RELEVANT

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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	17 August 2010	Gavriliu, Costin

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 10 16 1503

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
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