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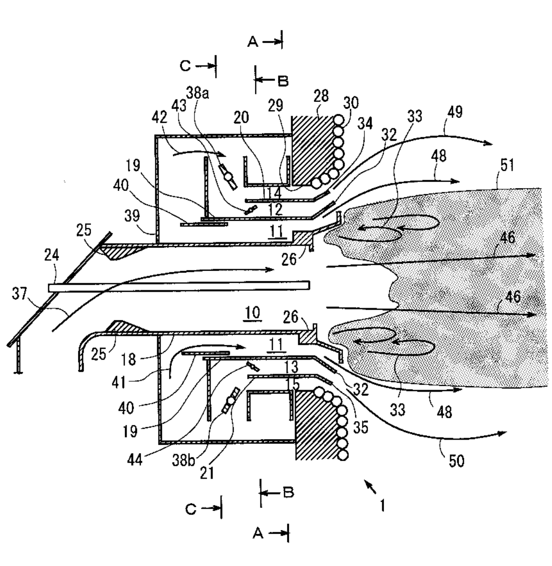
(54) SOLID FUEL BURNER, COMBUSTION APPARATUS USING SOLID FUEL BURNER, AND METHOD OF OPERATING THE COMBUSTION APPARATUS

(57) An air nozzle provided on the outer side of a fuel nozzle 10 of a solid fuel burner 1 is divided into a plurality of regions 12 to 17, and has means 43 and 44 for regulating air flow rates in nozzles 12 and 13 divided in the upper and lower direction. The nozzles (regions) 12 to 17 are connected to only the nozzle wall 19 and have obstacles 20 and 21 in the circumferential direction, dividing the inside of the nozzle into a plurality of regions, and by changing air flow rates in the respective regions in the outermost peripheral air nozzle, a deviation in momentum is caused in the vertical direction of the burner 1, a flame forming position is changed, and a combustion gas temperature at the furnace outlet, temperatures of a heat transfer tube installed on the furnace wall surface and a fluid flowing in the heat transfer tube or temperatures of heat transfer tubes provided in the furnace and a flue on the downstream side and temperatures of fluids flowing in the heat transfer tubes are controlled to be constant.

F I G. 1



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Description

Technical Field

[0001] The present invention relates to a solid fuel burner suitable for pulverizing a solid fuel, carrying by gas flow, performing suspension burning, and a combustion apparatus using the solid fuel burner and a method of operating the same.

Background Art

[0002] In combustion apparatuses (boilers, etc.), the steam temperature and pressure are increased and a reheating cycle is used for high efficiency. Normally, water supplied to a boiler passes through a heat transfer tube installed along a furnace wall surface and vaporizes, and passes through a superheater, becomes main steam and drives a steam turbine, and then becomes reheating steam and passes through a reheater, and is reheated and drives the steam turbine again, passes through a condenser and becomes water, and is supplied to the furnace again.

[0003] Thus, when the s team passes through a complicated fluid channel, it is important to obtain a prescribed heat-transfer amount at each heat-transfer portion. To obtain the prescribed heat-transfer amount, the temperature and flow rate of combustion gas at each heat transfer portion have to be controlled.

[0004] As a method of controlling the temperature and flow rate of the combustion gas, there is a conventional method in which a temperature distribution inside a furnace is controlled by vertically changing the ejection direction of fuel from the burner (Prior art document 1). There is also known a method in which on the downstream portion of a furnace, the combustion gas passage is divided, and the heat-transfer amount of the heat transfer portion installed in each combustion gas passage is adjusted by controlling the combustion gas amount flowing in each passage by using a means such as a damper.

Prior Art Document

[0005] U.S. Patent Specification No. 6439136 (Fig. 3)

Summary of the Invention

Problems to be solved by the Invention

[0006] In the conventional techniques described above, the direction of the fuel nozzle has to be mechanically changed when changing the ejection direction of fuel from the burner. Therefore, there was a problem of an increase in size of a drive mechanism. Especially, when a solid fuel is used as a fuel, wearing of a member for mechanically changing the direction of the fuel nozzle and ash adhesion must be taken into consideration to mechanically change the direction of the fuel nozzle. Moreover, , the portion facing the furnace have to be provided with a drive mechanism to change the fuel ejection direction from the fuel nozzle, and thermal deformation of the drive mechanism must be taken into consideration as well.

[0007] Ash adhesion in the combustion gas in the combustion gas passage for supplying fuel to the fuel nozzle must be taken into consideration sufficiently when the gas passage is divided and the combustion gas amount flowing in each gas passage is changed. Further, partitions are provided, and accordingly, the passages are narrowed, so that installation of the heat transfer portions must be sufficiently considered.

[0008] An object of the present invention is to provide a solid fuel burner which can keep constantly the combustion gas temperature at a furnace outlet, the temperatures of a heat transfer tube installed on a furnace wall surface and a heat transfer tube provided in a flue on the downstream side thereof, and the temperature of a fluid flowing in the heat transfer tubes by changing a flame forming position inside the furnace by controlling the direction of the fuel to be ejected to the furnace from the solid fuel burner vertically or horizontally by an air flow rate flowing in the air nozzle with a comparatively simple structure, and a combustion apparatus using the solid fuel burner and a method of operating the same.

Means for Solving the Problems

[0009] To achieve the object of the present invention, according to the present invention, a solid fuel burner includes: a fuel nozzle which ejects a mixture fluid of a solid fuel and its conveying gas, and at least one air nozzle which is disposed on the outer side of the fuel nozzle and ejects combustion air, wherein at least one air nozzle is formed to be annular on the outer periphery of the fuel nozzle, and the internal air passage is divided into a plurality of regions in the circumferential direction of the nozzle by an obstacle, and the solid fuel burner has means of regulating a flow rate for regulating a flow rate in at least one of the plurality of regions.

[0010] By dividing the air nozzle into a plurality of regions and changing the air flow rates in the respective regions, deviations of flow rate and momentum can be generated, in the flow ejected from the air nozzle, in the circumferential direction of the fuel nozzle.

[0011] For example, when the air volume flowing in the air nozzle on the lower side of the fuel nozzle is increased, the flow rate and flow velocity of air increase and the momentum increases at the nozzle outlet. At this time, ejected air involves ambient gasses and a negative pressure is generated in the region on the lower side of the fuel nozzle. Therefore, in the pressure distribution in the circumferential direction around the fuel nozzle, the negative pressure increases in the region on the lower side of the fuel nozzle. Accordingly, depending on the pressure distribution, a downward force is applied to the fuel ejected from the fuel nozzle into the furnace, and the fuel flows while being deflected downward, and a flame is formed at a lower portion inside the furnace than usual.

[0012] Therefore, the temperature distribution inside the furnace is biased to the lower side, the amount of heat absorption in the furnace increases, and the heat absorption in a heat transfer tube provided in a flue on the downstream side of the furnace can be reduced.

[0013] On the contrary, when the air flow rate in the air nozzle on the upper side of the fuel nozzle is increased, a flame is formed inside the furnace at an upper portion than usual and the temperature distribution inside the furnace is biased to the upper side than usual, and the amount of heat absorption in the furnace is reduced and the heat absorption in the heat transfer tube provided on the downstream portion of the furnace can be increased.

[0014] When the air nozzle is divided into a plurality of regions in the circumferential direction of the fuel nozzle as described above, an obstacle connected to the partition walls have to be provided in the radial direction of the air nozzle to connect the inner peripheral side partition wall and the outer peripheral side partition wall. However, in the solid fuel burner, the distance between the inner peripheral side partition wall and the outer peripheral side partition wall of the air nozzle may change during the operation of a combustion apparatus (boiler, etc.) due to an influence of thermal expansion, etc. For example, normally, the outer peripheral side partitionwall of the passage on the outermost peripheral side of the solid fuel burner is formed of a partition wall or a water wall of a furnace body constituting a furnace.

[0015] On the other hand, the inner peripheral side partition wall of the passage on the outermost peripheral side of the solid fuel burner is connected to a wind box to which the fuel nozzle or the burner is connected. The partition wall or water wall of the furnace body constituting the furnace is different in temperature from that of the fuel nozzle and the wind box during the operation of the combustion apparatus (boiler, etc.), so that they are different in ratio of thermal expansion. Therefore, in the solid fuel burner, the relative positions of the partition wall or water wall of the furnace body on the outer peripheral side of the air nozzle or the partition wall connected thereto (the partition wall of the furnace body side) and the partition wall (the partition wall of the fuel nozzle side) connected to the fuel nozzle or the wind box on the inner peripheral side change according to temperature. Therefore, it is difficult to divide the passage in the circumferential direction by providing an obstacle in the radial direction connecting the partition wall of the inner peripheral side and the partition wall of the outer peripheral side constituting the air nozzle.

[0016] Therefore, in the present invention, as a method of dividing the inside of the air nozzle into a plurality of regions in the circumferential direction (the direction crossing the gas flow), the structure shown as any of the following (A) to (C) was used.

[0017] (A) A structure has an obstacle which divides the inside of an air nozzle formed annularly into a plurality of regions in the circumferential direction, and the obstacle is connected to the partition wall of the inner peripheral side of the air nozzle, and is not connected to the partition wall of the outer peripheral side. The structure has means of regulating a flow rate for regulating the flow rate in at least one of the plurality of regions of the air nozzle, and a flow rate deviation is generated in the circumferential direction of the fuel nozzle in the flow ejected from the air nozzle.

[0018] In this case, a part of the air passes through the clearance between the obstacle and the partition wall of the outer peripheral side, however, most of the air remains in the same region. In the pressure distribution in the circumferential direction around the fuel nozzle caused by involving ambient gasses in the air flow ejected from the air nozzle into the furnace, a deviation is generated according to the flow rate deviation. Therefore, the fuel ejected from the fuel nozzle flows while deflecting to the side with a larger air volume ejected from the air nozzle.

[0019] (B) A structure has an obstacle which divides the inside of the air nozzle formed annularly into a plurality of regions in the circumferential direction, and the obstacle is connected to the partition wall of the outer peripheral side of the air nozzle, and is not connected to the partition wall of the inner peripheral side. The structure has means of regulating a flow rate for regulating the flow rate in at least one of the plurality of regions of the air nozzle, and a flow rate deviation is generated in the circumferential direction of the fuel nozzle in the flow ejected from the air nozzle.

[0020] In this case, a part of the air passes through the clearance between the obstacle and the partition wall of the inner peripheral side, however, most of the air remains in the same region. Therefore, like the method (A), the fuel ejected from the fuel nozzle flows while deflecting to the side with a larger air volume ejected from the air nozzle.

[0021] (C) A structure has an obstacle which divides the inside of the air nozzle formed annularly into a plurality of regions in the circumferential direction, and the obstacle includes an obstacle which is connected to the partition wall of the outer peripheral side of the air nozzle and is not connected to the partition wall of the inner peripheral side, and an obstacle which is connected to the partition wall of the inner peripheral side of the air nozzle and is not connected to the partition wall of the outer peripheral side. The structure has means of regulating a flow rate for regulating the flow rate in at least one of the plurality of regions of the air nozzle, and a flow rate deviation is generated in the circumferential direction of the fuel nozzle in the flow ejected from the air nozzle.

[0022] In this case, a part of the air passes through the clearance between the obstacle and the partition wall of the inner or outer peripheral side, however, most of the air remains in the same region. Therefore, like the methods (A) and (B), the fuel ejected from the fuel nozzle flows while deflecting to the side with a larger air volume ejected from the air nozzle.

[0023] The obstacles described in (A) to (C) above which divides the inside of the air nozzle into a plurality of regions in the circumferential direction are not limited to a configuration in which combustion air passes through the clearance between the obstacles and the air nozzle wall surface shown in Fig. 8 to Fig. 10, but may have a configuration in which the obstacle forms a closed space opened only at an inlet and an outlet in the combustion air flow direction, and combustion air is made to flow inside the closed space from the burner upstream side to the furnace side (The air nozzles for the combustion air may be called as divided air nozzles). A specific example of that is the tertiary air nozzles 12 and 13 formed by connecting and unifying two obstacles connected to the inner peripheral wall of the air nozzle shown in Fig. 3 and Fig. 4, and these are an embodiment of the air nozzle described in (A) above. Further, divided air nozzles formed by connecting and unifying two obstacles connected to the outer peripheral wall of the air nozzle described in (B) are also included in the scope of the present invention.

[0024] By regulating the air flow rate flowing in at least one air nozzle of the divided air nozzles disposed on the outer side of the fuel nozzle by means of regulating a flow volume, a flow rate deviation is generated in the circumferential direction of the fuel nozzle in the flows ejected from the divided air nozzles. Therefore, the fuel ejected from the fuel nozzle flows while deflecting to the side with a larger air volume ejected from the air nozzle.

[0025] By disposing the divided air nozzles positioned on the outer side of the fuel nozzle on the upper and lower sides of the fuel nozzle and regulating the flow rates and jet flow velocities of air ejected from the respective upper and lower air nozzles to the inside of the furnace, the momentum obtained as a product of the air flow rate and the jet flow velocity becomes different in the vertical direction of the burner outlet, and the air flow rates ejected from the upper and lower air nozzles of the burner can be individually controlled in the vertical direction inside the furnace at the burner outlet. Therefore, the temperature distribution inside the furnace differs in the vertical direction of the burner outlet, and the heat absorption in the furnace and the heat absorption in a heat transfer tube provided in a flue on the downstream side of the furnace change.

[0026] Thus, by the divided air nozzles provided on the upper and lower sides of the fuel nozzle, the controllability of the air flow rate in the burner is enhanced.

[0027] Further, by combination use of the divided air nozzles shown in Fig. 3 and Fig. 4 and an air nozzle to which two obstacles are not connected each other(not the divided ones) shown in Fig. 8 to Fig. 10, deviations in air flow rate and momentum can be encouraged.

[0028] Moreover, the configuration may be such that, in addition to the annular air nozzle, an air nozzle is disposed on the outer side of the annular nozzle and an obstacle which divides the inside of the annular air nozzle into a plurality of regions in the circumferential direction is disposed, and means of regulating a flow rate for regulating the air volume to be ejected from the air nozzle on the outer side of the annular nozzle is provided.

[0029] Also, the solid fuel burner of the present invention may also be configured so that the fuel nozzle outlet is shaped into a wide-width nozzle which is relatively short in one direction and is relatively long in the opposite direction at the fuel nozzle outlet (The length in one radial direction of the section in a direction crossing the passage of the fuel nozzle is longer than that in the other radial direction of the two directions orthogonal to each other), and an inner peripheral partition wall constituting at least one passage of the air nozzle also differs in length in the two directions orthogonal to each other, and the outer peripheral partition wall does not differ in length in the two directions orthogonal to each other.

[0030] By shaping the fuel nozzle outlet into the wide-width nozzle shape, the fuel ejected from the fuel nozzle easily scatters in the long side direction. For example, when the long side direction is orthogonal to the gas flow direction in the combustion apparatus (furnace), by scattering the fuel inside the furnace, the space inside the furnace can be effectively utilized and the fuel retention time in the furnace can be made longer than conventional method. Therefore, the discharge amount of nitrogen oxide (NOx) can be reduced, and unburned fuel can also be reduced.

[0031] Further, by adopting the configuration in which the fuel nozzle outlet is formed into a wide-width nozzle shape, and the inner peripheral partition wall constituting at least one air passage in the air nozzle differs in length in the long side direction and the short side direction, and the outer peripheral partition wall does not differ in length in the two directions orthogonal to each other, the thickness in one of the two directions orthogonal to each other of the section in a direction crossing the passage of the air nozzle increases. Therefore, when an air flow rate deviation is generated at the thicker portion, due to the large air flow rate, according to the deviation in air flow rate ejected from the air nozzle into the furnace, the fuel jet flow from the fuel nozzle can be easily guided.

[0032] In particular, in a combustion apparatus (furnace) in which combustion gas flows in the vertical direction, the outlet of the fuel nozzle of the solid fuel burner is formed into a shape with a longer side set in the horizontal direction, that is, a wide-width nozzle shape, and the thickness of the air nozzle described above is increased in the vertical direction, and a deviation in fuel flow rate is generated in the vertical direction, accordingly, the direction of the fuel jet flow from the solid fuel burner can be changed in the vertical direction. At this time, the retention time of combustion gas flowing in the combustion apparatus (furnace) changes, so that the heat transfer amount in the combustion apparatus changes, and the temperature of the combustion gas at the outlet can be changed.

[0033] Further, the solid fuel burner of the present invention is preferably provided with a ring for stabilizing flame as an obstacle for obstructing a flow of a mixture fluid flowing in the fuel nozzle or a flow of air flowing in the air nozzle, at the tip end of the outer peripheral side partition wall of the fuel nozzle or the tip end of the inner peripheral side partition wall of the air nozzle which includes the fuel nozzle.

[0034] By providing a ring for stabilizing flame which becomes an obstacle for flows of fuel and air ejected from respective nozzles on the partition wall between the fuel nozzle and the air nozzle, a negative pressure region is formed on the downstream of the ring for stabilizing flame by a pressure of the fluid flowing around thereof. In this negative pressure region, a circulation flow in a direction (from the downstream to the upstream) opposite to the direction ejected from each nozzle is formed.

[0035] Ahigh-temperature gas generated by combustion is returned from the downstream to the circulation flow, retained, and quickens ignition of fuel particles flowing around. The fuel jet flow ignited by the circulation flow flows while deflecting in the vertical direction due to air flow rate differences among the individual regions of the air nozzle, so that the forming position of flame can be changed. In particular, flame ignition is stably performed near the circulation flow at the fuel nozzle outlet and only the ignition forming direction can be changed, so that the temperature distribution in the furnace, the heat absorption in the furnace, and the heat absorption in a heat transfer tube provided in a flue on the downstream side of the furnace can be easily controlled.

[0036] The solid fuel burner of the present invention is preferably provided with the guide member that deflects the flow to the outer peripheral side (in the direction away from the fuel nozzle) on the outermost peripheral air nozzle outlet.

[0037] As a method of reducing nitrogen oxide (NOx) which is generated when burning the solid fuel, a method in which mixture of the fuel and air near the burner is suppressed and the fuel is burned under a condition with air shortage near the burner is available. In a burner using this method, when the air flow rate in the air nozzle is reduced, air is accompanied by the fuel jet flow and flows to the central axis side, and mixture with the fuel may be quickened. However, by providing a guide member for guiding the air ejection direction toward the outer peripheral side on the tip end of the air nozzle, the air direction ejected from the air nozzle is fixed to the outer peripheral side. Therefore, even when the air flow rate is particularly reduced, the mixture of the fuel and air near the burner can be suppressed.

[0038] The guide member preferably has a projection area in the burner axial direction occupying not less than 90% of the sectional area in the direction across the passage at the smallest portion (throat portion) of the air nozzle. By providing the projection area not less than 90%, the flow direction is guided to the outer periphery by the guide member.

[0039] Further, a flow velocity component radially outward of the fuel nozzle is induced in the air ejected from the air nozzle by the guide member. The flow of air ejected from the air nozzle into the furnace comes to easily involve ambient gasses radially outward, so that the gas pressure in the region between the air nozzle and the fuel nozzle becomes lower than the case where the guide member is not provided. Therefore, when a flow rate deviation in the circumferential direction of the fuel nozzle is generated in the air ejected from the air nozzle, the deflection of the fuel ejected from the fuel nozzle increases.

[0040] According to the requirements of the present invention, by regulating the air flow rates in the air nozzle, the forming position of flame can be controlled in the vertical direction or the horizontal direction inside the furnace at the fuel nozzle outlet. At this time, the air flow rates in the air nozzle of the solid fuel burner are preferably individually controlled in the vertical direction based on the combustion gas temperature at the furnace outlet, the temperature of a heat transfer tube installed on the furnace wall surface, the temperature of a fluid flowing in the heat transfer tube, the temperatures of the heat transfer tubes provided inside the furnace and a flue on the downstream side of the furnace or the temperatures of fluids flowing in the heat transfer tubes.

Effect of the Invention

[0041] According to the solid fuel burner of the present invention, the forming position of flame in a furnace can be controlled in the horizontal direction or the horizontal direction of the solid fuel burner by the air flow rate in the air nozzle, and the retention time of combustion gas flowing in the combustion apparatus (furnace) changes, so that the heat transfer amount in the combustion apparatus changes, and the temperature of the combustion gas at the outlet can be changed.

[0042] Further, according to a combustion apparatus (furnace) including the solid fuel burner and a method of operating the combustion apparatus of the present invention, the combustion gas temperature at the furnace outlet, the temperature of a heat transfer tube installed on the furnace wall surface, the temperature of a fluid flowing in the heat transfer tube, or the temperatures of heat transfer tubes provided inside the furnace and in a flue (refer to Fig. 14) on the downstream side of the furnace and the temperature of a fluid flowing in the heat transfer tube are kept constant, so that the forming position of flame can be changed.

Brief Description of the Drawings

[0043]

Fig. 1 is a schematic view showing a section of a solid fuel burner of a first embodiment of the present invention.

Fig. 2 is a schematic view showing the section of the solid fuel burner of the first embodiment of the present invention.

Fig. 3 is a sectional view taken along an arrow line A-A of the solid fuel burner of Fig. 1.

Fig. 4 is a sectional view taken along an arrow line B-B of the solid fuel burner of Fig. 1.

Fig. 5 is a sectional view taken along an arrow line C-C of the solid fuel burner of Fig. 1.

Fig. 6 is a view showing gas temperature behavior at a furnace outlet in a combustion apparatus including the solid fuel burner of the first embodiment of the present invention.

Fig. 7 is a schematic view showing a section of a solid fuel burner of a second embodiment of the present invention.

Fig. 8 is a sectional view taken along an arrow line C-C of the solid fuel burner of Fig. 7.

Fig. 9 is a sectional view taken along an arrow line C-C of another example of the solid fuel burner of Fig. 7.

Fig. 10 is a sectional view taken along an arrow line C-C of another example of the solid fuel burner of Fig. 7.

Fig. 11 is schematic view showing a section of a solid fuel burner of a third embodiment of the present invention.

Fig. 12 is a sectional view taken along an arrow line C-C of the solid fuel burner of Fig. 11.

Fig. 13 is a sectional view taken along an arrow line C-C of another example of the solid fuel burner of Fig. 11.

Fig. 14 is a schematic view of a combustion apparatus in which a solid fuel burner is provided on a furnace wall showing an embodiment of the present invention.

Description of Embodiments

[0044] Hereinafter, embodiments of the present invention will be described with reference to the drawings.

First embodiment

[0045] A first embodiment of the present invention will be described with reference to Fig. 1 to Fig. 5.

[0046] Fig. 1 is a schematic view showing a section of a solid fuel burner of a first embodiment of the present invention. Fig. 2 is a schematic view showing the status of forming flame when a deviation is generated in an air flow rate ejected from an air nozzle into a furnace with respect to the solid fuel burner. Fig. 3 is a sectional view taken along an arrow line (sectional view taken along an arrow line A-A of Fig. 1) at the furnace partition wall portion of the solid fuel burner shown in Fig. 1, Fig. 4 is a sectional view taken along an arrow line (sectional view taken along an arrow line B-B of Fig. 1) at the wind box portion of the solid fuel burner shown in Fig. 1, and Fig. 5 is a sectional view taken along an arrow line (sectional view taken along an arrow line C-C of arrows of Fig. 1) at the wind box portion of the solid fuel burner shown in Fig. 1.

[0047] In Fig. 1, a fuel nozzle 10 which supplies and conveys a mixture fluid of primary air and solid fuel in the solid fuel burner 1 is connected to a conveying tube on the upstream side, not shown, and on the outer periphery of the fuel nozzle 10, an annular secondary air nozzle 11 which ejects secondary air is provided. On the outer periphery of the secondary air nozzle 11, tertiary air nozzles 12 and 13 which eject tertiary air are provided. On the outer periphery of the tertiary air nozzles 12 and 13, quaternary air nozzles 14 to 17 which eject quaternary air are provided. The tertiary air nozzles 12 and 13 of the present embodiment are divided air nozzles provided on the upper and lower sides across the fuel nozzle 10. The quaternary air nozzles 14 to 17 are outermost peripheral air nozzles forming a passage on the outermost periphery in the solid fuel burner 1 of the present embodiment.

[0048] Here, the layout of the nozzles 10 to 17 and the configuration of the partition walls to be provided for the nozzles 10 to 17 will be described based on Fig. 3.

[0049] The partition wall 18 constituting the fuel nozzle 10 commonly serves as an inner peripheral wall of the secondary air nozzle 11 provided annularly on the outer periphery of the fuel nozzle 10. Also, the outer peripheral wall 19 of the secondary air nozzle 11 commonly serves as inner peripheral walls of the tertiary air nozzles 12 and 13 and the quaternary air nozzles 16 and 17. The upper tertiary air nozzle 12 and the lower tertiary air nozzle 13 are disposed so as to sandwich the fuel nozzle 10, a cylindrical partition wall 19 and a bent-plate-shaped peripheral wall obstacle 20 constitute the upper tertiary air nozzle 12, and the cylindrical partition wall 19 and a bent-plate-shaped obstacle 21 constitute the lower tertiary air nozzle 13. The quaternary air nozzles 14 to 17 are divided into respective regions by the peripheral wall obstacles 20 and 21, however, the partition wall 19 on the outer peripheral side and the partition wall 19 on the inner peripheral side are separated from each other. The quaternary air nozzle 14 is provided on the outer peripheral upper side of the tertiary air nozzle 12, the quaternary air nozzle 15 is provided on the outer peripheral lower side of the tertiary air nozzle 13, the quaternary air nozzle 16 is provided on the outer side of the partition wall 19 of the tertiary air nozzle and the obstacles 20 and 21 on the left side as viewed from the furnace side, and the quaternary air nozzle 17 is provided on the outer side of the partition wall 19 of the tertiary air nozzle and the peripheral wall obstacles 20 and 21 on the right side as viewed from the furnace side.

[0050] Next, a configuration and a combustion state of the burner will be described based on Fig. 1.

[0051] An oil gun 24 is provided to penetrate through the central portion of the fuel (pulverized coal) nozzle 10, and is used for assisting combustion when starting up the burner and during low-load combustion. For preventing backfire of the solid fuel, a restriction 25 is provided in the fuel nozzle 10. At the tip end of the partition wall 18 between the fuel nozzle 10 and the secondary air nozzle 11, a ring for stabilizing flame 26 is provided, and the ring for stabilizing flame 26 has a function to expand circulation flows 33 generated by mixing a mixture fluid of the fuel and primary air with secondary air inside the furnace near the tip end portion of the fuel (pulverized coal) nozzle 10.

[0052] An opening portion in which the burner 1 on the furnace wall 28 is installed, is a burner throat portion 29, and the burner throat portion 29 commonly serves as outer peripheral partition walls of the quaternary air nozzles 14 to 17. On the wall surface except for the burner throat portion 29 of the furnace wall 28, a water tube 30 is provided.

[0053] On the tip end of the partition wall 19 between the secondary air nozzle 11 and the tertiary air nozzles 12 and 13, a guide member (guide sleeve) 32 which guides secondary air and tertiary air in the direction away from the fuel nozzle 10 is provided, and on the tip ends of the peripheral wall obstacles 20 and 21 between the tertiary air nozzles 12 and 13 and the quaternary air nozzles 14 and 15, guide members (guide sleeves) 34 and 35 which guide tertiary air and quaternary air in the direction away from the fuel nozzle 10 are provided respectively.

[0054] Air flowing in these combustion air nozzles 11 to 17 is supplied from a wind box 39 surrounding the burner 1.

[0055] In the fuel (pulverized coal) nozzle 10, a flow 37 of a mixture fluid of the solid fuel and the primary air flows, and in the secondary air nozzle 11, a flow 41 of the secondary air flows. Moreover, the upstream sides of the tertiary air nozzles 12 and 13 and the quaternary air nozzles 14 to 17 form the same air passage, and an air flow 42 to be used as the tertiary air and the quaternary air is regulated by flow regulators (dampers) 38a, 38b, 43, and 44.

[0056] Further, the flow rate of the secondary air flow 41 flowing in the secondary air nozzle 11 is regulated by the flow regulator (damper) 40, and in the air flow 42 to be used as tertiary air and quaternary air, the total flow rate of which is regulated by the flow regulator (damper) 38, air in the tertiary air nozzles 12 and 13 to be used as tertiary air is respectively regulated by the flow regulators (dampers) 43 and 44.

[0057] A flow 46 of a mixture fluid (fuel jet flow) of the solid fuel and primary air ejected from the fuel nozzle 10 into the furnace, a flow 48 of secondary air ejected from the secondary air nozzle 11 into the furnace, flows 49 and 50 of tertiary air and quaternary air (in Fig. 1, the tertiary air and the quaternary air in the furnace are not discriminated but are shown as an upper flow 49 and a lower flow 50) ejected from the tertiary air nozzles 12 and 13 and the quaternary air nozzles 14 to 17 into the furnace, are formed. Further, in the furnace, an outer peripheral portion of flame (fuel jet flow) 51 is formed.

[0058] In combustion of the solid fuel in the solid fuel burner 1, air in the region on the downstream side of the partition wall 18 separating the fuel nozzle 10 and the secondary air nozzle 11 is involved in flows ejected from the respective nozzles 10 and 11. Therefore, in the region on the downstream side of the partition wall 18, the pressure is reduced, and circulation flows 33 as flows from the downstream side to the upstream side are formed.

[0059] When the ring for stabilizing flame 26 is provided on the tip end portion of the partition wall 18, the flow 46 of the fuel mixture fluid and the flow 48 of the secondary air in the furnace are separated and the circulation flows 33 expand. A high-temperature gas is retained in the circulation flows 33, so that ignition of fuel particles is promoted and the flame stability is improved.

[0060] Further, a flame is formed near the outlet of the fuel nozzle 10 and the oxygen consumption is advanced, and accordingly, a reducing flame region with a lower oxygen concentration expands in the flame. In this reducing flame, nitrogen contained in the solid fuel is emitted as a reducing substance such as ammonia or cyan, and acts as a reducing agent for reducing the nitrogen oxide (NOx) to nitrogen. Therefore, the NOx evolution amount can be reduced.

[0061] Further, the ignition is quickened, so that the combustion reaction of the solid fuel is advanced and the unburned fuel in the fuel ash (hereinafter, referred to as unburned amount) is also reduced. By providing guide members 32, 34, and 35 for guiding air to be ejected from the respective air nozzles toward the outer periphery at the outlets of the tertiary air nozzles 12 and 13 and the quaternary air nozzles 14 to 17, the flow 46 of the fuel mixture fluid, the flow 48 of the secondary air, and the flows 49 and 50 of the tertiary air and the quaternary air flow in the furnace are made to flow separately from each other, so that mixture of the fuel, the tertiary air, and the quaternary air near the burner is delayed and the reducing flame region expands.

[0062] Next, features of the present embodiment will be described with reference to Fig. 1 and Fig. 2.

[0063] Fig. 1 is the case where air is made to flow so that the velocities of jet flows from the tertiary air nozzles 12 and 13 become equal to each other, and Fig. 2 is in the case where the flow regulating damper 43 of the tertiary air nozzle 12 installed on the upper side of the burner 1 is operated so that a smaller amount of air flows in the tertiary air nozzle than in other nozzles.

[0064] As shown in Fig. 2, when the air volume on the lower side of the burner 1 is increased, in the jet flows from the tertiary air nozzles 12 and 13, the air flow rate and jet flow velocity from the upper air nozzle 12 are reduced, and the air flow rate and jet flow velocity from the lower air nozzle 13 are increased. The momentum obtained as a product of the flow rate and the jet flow velocity also becomes larger on the lower side of the burner 1 than on the upper side of the burner 1. The jet flows of the tertiary air involve ambient gasses at the outlet of the burner 1, so that a negative pressure is generated. When the air volume of the air nozzle 13 on the lower side of the burner 1 is increased as shown in Fig. 2, in the pressure distribution around the tertiary air nozzles 12 and 13, the negative pressure increases more in the lower tertiary air nozzle 13, and a pressure differs in the vertical direction at the outer peripheral portion of the secondary air nozzle 11. On the lower side with the higher negative pressure, the secondary air 48 easily deflects downward and flows. Therefore, at the outer peripheral portion of the fuel nozzle 10, the secondary air 48 also deflects downward from the burner 1 and flows, so that the negative pressure increases downward in the furnace. Therefore, the fuel jet flow (flame) 51 also deflects downward.

[0065] That is, the fuel jet flow 51 is formed in the furnace as a downward flow due to a deviation between the air flow rates in the tertiary air nozzles 12 and 13. Further, the fuel flows downward, and accordingly, the flame to be formed from the circulation flows 33 on the downstream of the ring for stabilizing flame 26 is also formed downward. Therefore, the temperature distribution in the furnace is biased to the lower side, and the amount of heat absorption in the furnace can be increased and the amount of heat absorption in the heat transfer tube provided on the downstream portion of the furnace can be reduced.

[0066] In addition, contrary to Fig. 2, when the damper for regulating flow 44 of the tertiary air nozzle 13 installed on the lower side of the burner 1 is operated and the air flow rate on the upper side is relatively increased, the flame is formed inside the furnace at an upper portion than usual, and the temperature distribution in the furnace is biased to the upper side, and the amount of heat absorption in the furnace can be reduced and the amount of heat absorption in the heat transfer tube provided in the flue of a downstream side of the furnace can be increased.

[0067] According to this embodiment, the position for forming the flame 51 can be controlled in the vertical direction by generating a deviation between air flow rates in the tertiary air nozzles 12 and 13. Therefore, based on the combustion gas temperature at the furnace outlet, the temperature of a heat transfer tube installed on the furnace wall surface, the temperature of the fluid flowing in the heat transfer tube, or the temperatures of heat transfer tubes provided in the furnace and a flue on the downstream side thereof and the temperatures of fluids flowing in the heat transfer tubes, the air flow rates in the tertiary air nozzles 12 and 13 of the solid fuel burner 1 can be individually controlled in the vertical direction.

[0068] In the solid fuel burner 1 of the present embodiment, at the tip end of the outer peripheral side partition wall 18 of the fuel nozzle 10, a ring for stabilizing flame 26 which obstructs the flow of the mixture fluid 37 flowing in the fuel nozzle 10 and the flow of air flowing in the secondary air nozzle 11 is provided. Further, guide members 32, 34 and 35 which deflect flows to the outer peripheral side (the direction away from the fuel nozzle 10) are provided at the outlets of the tertiary air nozzles 12 and 13 and the quaternary air nozzles 14 to 17.

[0069] By providing the ring for stabilizing flame 26, the circulation flows 33 are formed inside the furnace, and a high-temperature gas is retained in the circulation flows 33, and by igniting the fuel, the flame can be stably ignited and formed on the downstream side of the ring for stabilizing flame 26 at the outlet of the fuel nozzle 10. Therefore, regardless of the flow rates of air ejected from the tertiary air nozzles 12 and 13, the ignition position can be fixed. Therefore, even when a deviation is generated between air flow rates ejected from the tertiary air nozzles 12 and 13, only the forming direction (angle) of the flame 51 can be changed. The start position of forming the flame 51 does not change and only the angle of the flame 51 changes, so that the temperature distribution or the amount of heat absorption in the furnace and that in a heat transfer tube provided on the downstream portion of the furnace are easily controlled.

[0070] Further, the guide members 32, 34, and 35 are provided, so that the direction of the air ejected from the air nozzles 11 to 17 can be always set toward the outer peripheral side of the burner 1. Therefore, particularly, even when the flow rate is reduced, mixing the fuel and air near the burner 1 inside the furnace can be suppressed. Therefore, mixing fuel and air near the burner 1 inside the furnace can be suppressed and NOx can be reduced.

[0071] As dampers for regulating air flow rate, the respective dampers 40, 43, and 44 corresponding to the secondary air nozzle 11 and the tertiary air nozzles 12 and 13 are shown in the present embodiment, however, as shown in Fig. 5, dampers for regulating the flow rate which regulate the air volume in the tertiary air nozzles 12 and 13 and the quaternary air nozzles 14 to 17 may be provided as flow regulating dampers 38a and 38b respectively provided for the upper and lower quaternary air nozzles 14 and 15 and flow regulating dampers 56a and 56b provided for the left and right quaternary air nozzles 16 and 17.

[0072] In this case, by the flow regulating dampers 38a, 38b, 56a and 56b, a deviation between the air flow rate in the tertiary air nozzles 12 and 13 and the quaternary air nozzles 14 to 17 can be generated each other. Fig. 6 shows gas temperature changes at the furnace outlet respectively when a deviation in the flow rate is generated in the vertical direction of the burner 1 by operating the flow regulating dampers 38a and 38b which regulate the air volume in the quaternary air nozzles 14 and 15 of the solid fuel burner 1 of the first embodiment, and when a deviation in the flow rate is generated in the vertical direction of the burner 1 by operating the flow regulating dampers 43 and 44 of the tertiary air nozzles 12 and 13.

[0073] As shown in Fig. 6, the gas temperature at the furnace outlet changes by the deviation in the air flow rate in the vertical direction of the air nozzles of the burner 1. The gas temperature change at the furnace outlet shows an increase or a decrease in heat absorption in the furnace. For example, a decrease of a gas temperature means an increase in heat absorption in the furnace and facilitation of cooling of combustion gas.

[0074] The results shown in Fig. 6 show that the quaternary air nozzles 14 to 17 have passages connected to each other, so that the same effect can be obtained although the effect of flow rate regulation by the dampers 38 and 56 is smaller than that by the dampers 43 and 44 of the tertiary air nozzles 12 and 13.

[0075] As described above, when the air nozzles 12 to 17 are divided in the circumferential direction into a plurality of regions, the partition walls 19 and 29 and the peripheral wall obstacles 20 and 21, etc., must be provided. Normally, in the solid fuel burner 1, similar to the quaternary air nozzles 14 to 17 shown in Fig. 3, the outer peripheral side partition wall 29 of the passage on the outermost periphery is a furnace body partition wall 28 or a water wall 30 constituting the furnace. On the other hand, the inner peripheral side partition wall 19 and the peripheral wall obstacles 20 and 21 are connected to the wind box 39 to which the fuel nozzle 10 and the burner 1 are connected. The fuel nozzle 10 and the wind box 39 are different in thermal expansion rate caused by operation of the combustion apparatus (boiler) from that of the furnace body partition wall 28 or the water wall 30. Therefore, in the solid fuel burner 1, the relative positions of the outer peripheral side partition wall 29 of the passage on the outermost periphery and the inner peripheral side partition wall 19 and peripheral wall obstacles 20 and 21 change according to the temperature, so that they must be installed independently each other. Therefore, it is difficult to connect the inner peripheral side partition wall 19 and peripheral wall obstacles 20 and 21 to the outer peripheral side partition wall 29. Therefore, in the present embodiment, the quaternary air nozzles 14 to 17 are divided into four regions by the obstacles 20 and 21 connected to only the tertiary air nozzles 12 and 13, so that the effect of flow rate regulation is obtained.

Second embodiment

[0076] Fig. 7 is a schematic view showing a section of a solid fuel burner of a second embodiment of the present invention. In addition, Fig. 8 is a sectional view taken along an arrow line C-C of the solid fuel burner shown in Fig. 7.

[0077] The second embodiment is different from the first embodiment shown in Fig. 1 to Fig. 5 in that the divided tertiary air nozzles 12 and 13 of the first embodiment are not provided and the outermost peripheral nozzle regions 14 to 17 are divided in the circumferential direction in Fig. 7 and Fig. 8.

[0078] The outermost peripheral air nozzle is divided by obstacles 53 and 54 into the regions 14 to 17 in which air corresponding to the tertiary air flows in this burner 1. The regions 14 to 17 to be connected to the wind box 39 include the upper region 14, the lower region 15, the left region 16 and the right region 17 as viewed from the furnace side, and can individually regulate air flow rates by dampers for regulating the flow rate 38a and 38b provided in the upper and lower regions 14 and 15 and dampers for regulating the flow rate 56a and 56b provided in the left and right regions 16 and 17, respectively.

[0079] The obstacles 53 and 54 are connected to the partition wall 19 on the inner peripheral side of the outermost peripheral air nozzle, and are not connected to the partition wall 29 on the outer peripheral side (burner throat portion which is an opening portion of the furnace wall 28 in which the burner 1 is installed). By providing the obstacles 53 and 54, movement of combustion air among the regions 14 to 17 is obstructed. Therefore, by the flow rate regulator (dampers) 38a, 38b, 56a and 56b, the air volume ejected from the regions 14 to 17 into the furnace can be regulated by the flow rate regulator (dampers) 38a, 38b, 56a and 56b.

[0080] Specifically, the air flow rate and air jet flow velocity flowing in the upper region 14 are reduced by squeezing the damper 38a. Accordingly, the air flow rate and air jet flow velocities in other regions 15 to 17 increase. Therefore, as the air momentum obtained as a product of the air flow rate and the air jet flow velocity, downward momentum increases with respect to the circumferential direction of the fuel nozzle 10. The air jet flow ejected from the outermost peripheral air nozzle into the furnace involves ambient gasses at the outermost peripheral air nozzle outlet, so that a negative pressure is generated. The momentum in the outermost peripheral air nozzle is increased downward, and accordingly the negative pressure on the lower side is increased at the outermost air nozzle outlet. Therefore, the flow 48 of the secondary air in the furnace, flowing near the outermost peripheral air nozzle, flows while deflecting downward in the furnace. Further, the negative pressure on the lower side portion in the circulation flow 33 is also increased due to the flow 48 of the secondary air, so that the fuel jet flow 46 flowing near the circulation flow 33 also deflects downward.

[0081] That is, due to a deviation of air flow rates in the regions 14 to 17 of the outermost air nozzle, the fuel jet flow 46 is formed as a downward flow in the furnace. Further, the fuel flows downward, and accordingly, the flame 51 is also formed downward. Therefore, the temperature distribution in the furnace is biased to the lower side, and the amount of heat absorption in the furnace can be increased and the heat absorption in a heat transfer tube provided in the flue on the downstream side of the furnace can be reduced.

[0082] Further, in the present embodiment, obstacles 53 and 54 that divide the combustion air nozzle of the solid fuel burner 1 in the circumferential direction into a plurality of regions are provided as described above. Normally, the outer peripheral side partition wall 29 of the solid fuel burner 1 is composed of a furnace partition wall 28 or the water wall 35 which constitutes the furnace, and the inner peripheral side partition wall 19 of the regions 14 to 17 of the outermost peripheral air nozzle is connected to the wind box 39 to which the fuel nozzle 10 and the burner 1 are connected. The outer peripheral side partition wall 29 and the inner peripheral side partition wall 19 are different in thermal expansion caused by operation of the combustion apparatus (boiler). Therefore, the relative positions of the outer peripheral side partition wall 29 and the inner peripheral side partition wall 19 in the solid fuel burner 1 change according to temperature, so that both of them must be installed independently. Therefore, it is difficult to connect the inner peripheral side partition wall 19 and the outer peripheral side partition wall 29.

[0083] In the present embodiment, the outermost peripheral air nozzle is divided into a plurality of regions, however, the obstacles 53 and 54 are not connected to the outer peripheral side partition wall 29. Therefore, a deviation in the flow rate can be generated in the circumferential direction of the fuel nozzle 10 without influences from fluctuation of the relative positions of the outer peripheral side partition wall 29 and the inner peripheral side partition wall 19 due to the thermal expansion difference. Also, in the description given above, the direction of forming flame in the vertical direction inside the furnace is described, however, it is also possible that the direction of forming flame is deflected to the left or right by generating a deviation in the flow rate of the combustion air flowing in the regions 16 and 17 for forming flame in the horizontal direction in the furnace.

[0084] In the second embodiment shown in Fig. 7 and Fig. 8, the obstacles 53 and 54 are connected from the inner peripheral side partition wall 19, however, it is also possible that, as shown in Fig. 9, the obstacles 53 and 54 are connected to the outer peripheral side partition wall 29 and separated from the inner peripheral side partition wall 19. Alternatively, as shown in Fig. 10, it is also possible that the obstacles 53 and 54 are connected to only the inner peripheral side partition wall 19, the obstacles 60 and 61 are connected to only the outer peripheral side partition wall 29, and obstacles 53, 54, 60, and 61 respectively connected to both of the inner peripheral side and the outer peripheral side are provided doubly. By providing obstacles doubly, air movement among the regions 14 to 17 is further reduced.

[0085] Moreover, in the present embodiment, the secondary air nozzle 11 is provided on the outer peripheral portion of the fuel nozzle 10, however, even when the secondary air nozzle 11 is not provided and the fuel nozzle 10 is in contact with the regions 14 to 17 of the outermost peripheral air nozzle, the deflection effect of the position for forming flame by the above-described air flow rate deviation is similarly obtained.

Third embodiment

[0086] Fig. 11 is a schematic view showing a section of a solid fuel burner of a third embodiment of the present invention. Fig. 12 is a sectional view taken along an arrow line C-C of Fig. 11.

[0087] The difference of the embodiment shown in Fig. 11 and Fig. 12, from the second embodiment shown in Fig. 7 and Fig. 8 is that, for example, the fuel nozzle 10 and the secondary air nozzle 11 are relatively short in diameter in the vertical direction and relatively long in diameter in the horizontal direction orthogonal thereto, that is, wide-width nozzles. In the present embodiment, an example of the fuel nozzle 10 and the secondary air nozzle 11 whose longer side is formed in the horizontal direction is shown. Moreover, the outer peripheral partition wall 29 of the respective regions 14 to 17 of the outermost peripheral air nozzle has a circular shape whose length in the vertical direction and the horizontal direction is equal.

[0088] The fuel nozzle 10 and the secondary air nozzle 11 become so-called planiform, so that the thickness of the outermost peripheral air nozzle in the sectional direction across the passages of respective regions 14 to 17 is thicker in one of two directions orthogonal to each other. Therefore, when a deviation in the flow rate is generated at the thicker portion, due to larger flow rate, the fuel jet flow ejected from the fuel nozzle 10 into the furnace can be easily guided by a deviation among flow rates ejected from the regions 14 to 17 of the outermost peripheral air nozzle.

[0089] In the third embodiment of the present invention shown in Fig. 11 and Fig. 12, the air nozzles are provided as the secondary air nozzle 11 and the regions 14 to 17 of the outermost peripheral air nozzle, however, as shown Fig. 13, on the inner sides of the regions 14 to 17 of the outermost peripheral air nozzle, tertiary air nozzles 12 and 13 served as the divided air nozzles may be provided. In this case, as shown in Fig. 13, the peripheral wall obstacles 20 and 21 of the divided tertiary air nozzles 12 and 13 may also be used as obstacles which divide the regions 14 to 17 of the outermost peripheral air nozzle.

Fourth embodiment

[0090] Fig. 14 is a schematic view of a combustion apparatus including a solid fuel burner according to the first embodiment of the present invention provided on the furnace wall.

[0091] The solid fuel burner 1 includes a fuel nozzle 10 and air nozzles 12 and 13. In the present embodiment, for describing a deviation of the air amount in the vertical direction, the air nozzles 12 and 13 are provided on the upper and lower sides, however, any of the burners 1 of the first to third embodiments described above is applicable.

[0092] The fuel nozzle 10 is connected to the solid fuel pulverizer 66, a carrier air fan 67, and a fuel hopper 68 through a fuel carrying tube for carrying fuel 65 on the upstream thereof. Moreover, the air nozzles 12 and 13 are connected to an air fan 70 via valves for regulating flow volume71 and 72.

[0093] Generally, a plurality of the above-described solid fuel burners 1 are connected to the furnace 74, however, in the present embodiment, an example to which one solid fuel burner 1 is connected is described.

[0094] The partition wall 28 constituting the furnace 74 is composed of a water tube and absorbs combustion heat. Further, heat transfer surfaces 76 hung down from the ceiling inside the furnace 74 and a heat transfer surface 76 disposed in a flue on the downstream side of the furnace 74 are provided. Moreover, for measuring the amount of heat absorption on the water tube 30 (refer to Fig. 1) on the wall surface of the furnace 74 or on the heat transfer surface 76, a plurality of thermometers (not shown) for measuring the temperatures of water and steam or the temperatures of materials constituting the water tube 30 or the heat transfer tube are respectively provided at appropriate positions.

[0095] A control processor 73 is provided shown in Fig. 14, which controls valves for regulating flow amount 71 and 72 based on a steam temperature at the water tube outlet and a steam temperature at the outlet of the heat transfer surfaces 76. In the embodiment shown in Fig. 14, air from the air nozzles 12 and 13 formed to sandwich the fuel nozzle 10 in the vertical direction is ejected while being respectively inclined to the opposite direction to the fuel nozzle 10.

[0096] When the air flow rate in the lower side air nozzle 13 is increased, the jet flow velocity also increases. The momentum obtained as a product of the flow rate and the jet flow velocity is also increased in the axial direction, and also inside the furnace 74, the downward momentum increases. The air jet flow involves ambient gasses at the outlet of the fuel nozzle 10, so that a negative pressure is generated, and due to the negative pressure, the fuel jet flow flowing near the air jet flow also deflects downward and flows.

[0097] That is, due to a deviation between air flow rates ejected from the air nozzles 12 and 13, a fuel jet flow ejected from the fuel nozzle 10 is formed as a downward flow at the outlet of the burner 1 of the furnace. Further due to the downward flow of the fuel, the flame to be formed inside the furnace 74 from the solid fuel burner 1 is also formed downward. Therefore, the temperature distribution inside the furnace 74 is biased to the lower side, and the amount of heat absorption in the furnace 74 can be increased and the amount of heat absorption by the heat transfer surface 76 provided in the flue on the downstream side of the furnace 74 can be reduced.

[0098] When the air flow rate of the upper side air nozzle 12 is increased, the flame to be formed at the outlet of the burner 1 is formed to be at an upper portion than usual, the temperature distribution inside the furnace 74 is biased to the upper side, and the heat absorption in the furnace 74 can be reduced and the amount of heat absorption by the heat transfer surface 76 provided in the flue on the downstream side of the furnace 74 can be increased.

[0099] Gas temperature changes at the furnace outlet when the burner structure shown in the first embodiment of the present invention described above are applied to the furnace 74 shown in Fig. 14 are as shown in Fig. 6. As shown in Fig. 6, in acombustion apparatus including the solid fuel burner 1 of the present invention provided on the furnace wall, due to the air flow rate deviation in the vertical direction of the burner 1, the gas temperature at the outlet of the furnace 74 changes. A gas temperature change at the outlet of the furnace 74 shows an increase/decrease in heat absorption inside the furnace 74. For example, a gas temperature decrease means that the amount of heat absorption in the furnace 74 increases and cooling of the combustion gas is advanced.

[0100] According to the present embodiment, by changing the flame forming position by controlling the valves for regulating flow volume 71 and 72 via the control processor 73, the amount of heat absorption on each heat transfer surface 76 can be changed. As for the steam temperature flowing on the wall of the furnace 74 and the heat transfer surface 76, a predetermined design temperature is set for protecting materials of a turbine installed on the downstream side and a heat transfer surface on the upstream side, and the steam temperature can be kept in the design temperature range by changing the amount of heat absorption.

[0101] In particular, when ash adhering to the heat transfer surface 76 is removed, the amount of heat absorption may be temporarily increased. In this case, the steam temperature fluctuates, however, the steam temperature fluctuation can be suppressed by changing the position for forming flame as described above. Further, steam temperature fluctuation due to a load change or a change in the kind of fuel can also be suppressed.

Industrial Applicability

[0102] The present invention provides a solid fuel burner which can easily change a heat absorption position inside a combustion apparatus, and is highly applicable to a furnace of a boiler, etc., with high combustion efficiency.

Description of the Reference Numerals

[0103]

1 Solid fuel burner 10 Fuel nozzle
12, 13 Tertiary air nozzle
14 to 17 Quaternary air nozzle (outermost peripheral nozzle region)
18, 19 Partition wall 20, 21 Peripheral wall obstacle
24 Oil gun 25 Restriction
26 Obstacle (ring for stabilizing flame)
28 Furnace wall (furnace body partition wall)
29 Burner throat portion (outer peripheral side partition wall of outermost peripheral passage)
30 Water wall (water tube)
32, 34, 35 Guide member (guide sleeve)
33 Circulation flow
37 Flow of mixture fluid of solid fuel and primary air

38, 40, 43, 44 Flow rate regulator (damper)
39 Wind box 41 Flow of secondary air
42 Air flow to be used as tertiary air and quaternary air
46 Flow of mixture fluid (fuel jet flow) in furnace
48 Flow of secondary air in furnace
49, 50 Flows of tertiary air and quaternary air in furnace 51 Outer peripheral portion of flame (fuel jet flow) in furnace 53, 54 Obstacle 56 Flow rate regulator (damper)
65 Tube for carrying fuel
66 Solid fuel pulverizer
67 Carrier air fan 68 Fuel hopper
70 Air fan
71, 72 valves for regulating flow volume
73 Control processor 74 Furnace
76 Heat transfer surface

Claims

1. A solid fuel burner comprising: a fuel nozzle which ejects a mixture fluid of a solid fuel and a conveying gas; and at least one air nozzle which is disposed on the outer side of the fuel nozzle and ejects combustion air, wherein
at least one air nozzle is formed to be annular on the outer periphery of the fuel nozzle, and the internal air passage of the annular air nozzle is divided into a plurality of regions in the circumferential direction of the annular air nozzle by an obstacle, and the solid fuel burner has means of regulating a flow rate for regulating an air flow rate flowing in at least one of the plurality of divided regions.

2. The solid fuel burner according to Claim 1, wherein obstacles for dividing the internal air passage of the annular air nozzle into a plurality of regions in the circumferential direction of the air nozzle are, (a) obstacles connected to only an inner peripheral side partition wall constituting the air nozzle, (b) obstacles connected to only an outer peripheral side partition wall of the air nozzle, or (c) double obstacles formed by combining an obstacle connected to only the inner peripheral side partition wall and obstacles connected to only the outer peripheral side partition wall.

3. The solid fuel burner according to Claim 1 or 2, wherein a sectional shape in a direction across a passage on the outlet side of the fuel nozzle is relatively short in length in one radial direction of the fuel nozzle and relatively long in length in a radial direction orthogonal to the one radial direction, and
an inner peripheral partition wall constituting at least one air passage in the air nozzles has a sectional shape in a direction across the air passage which is relatively short in length in one radial direction of the air nozzle and relatively long in length in a radial direction orthogonal to the one radial direction, and an outer peripheral partition wall is equal in length in one radial direction and in a radial direction orthogonal to the one radial direction.

4. The solid fuel burner according to Claim 3, wherein the sides of which the lengths in one radial direction of the fuel nozzle and the air nozzle are relatively short are formed in the vertical direction, and the sides of which the lengths in a radial direction orthogonal to the one direction are relatively long are formed in the horizontal direction.

5. The solid fuel burner according to Claim 1, comprising: in addition to the annular air nozzle, an air nozzle disposed on the outer side of the annular air nozzle; and means of regulating a flow rate for regulating an air volume to be ejected from the air nozzle disposed on the outer side of the annular air nozzle.

6. The solid fuel burner according to Claim 5, wherein obstacles which divide the inside of the annular air nozzle into a plurality of regions in the circumferential direction of the air nozzle are connected to the outer wall surface of the fuel nozzle.

7. The solid fuel burner according to Claim 5, wherein a part of the air nozzle divided into the plurality of regions provided on the outer periphery of the air nozzle formed annularly on the outer periphery of the fuel nozzle has air passages only on the upper side and the lower side of the fuel nozzle, and the air passage includes an obstacle connected to only the inner peripheral side partition wall of the air passage, and the obstacle forms a closed space opened at only inlet and outlet of combustion air flow direction.

8. The solid fuel burner according to Claim 1, wherein at an outlet of at least one air nozzle of the air nozzles, guide members which deflect an air flow to the outer peripheral side direction of the air nozzle away from the fuel nozzle are provided.

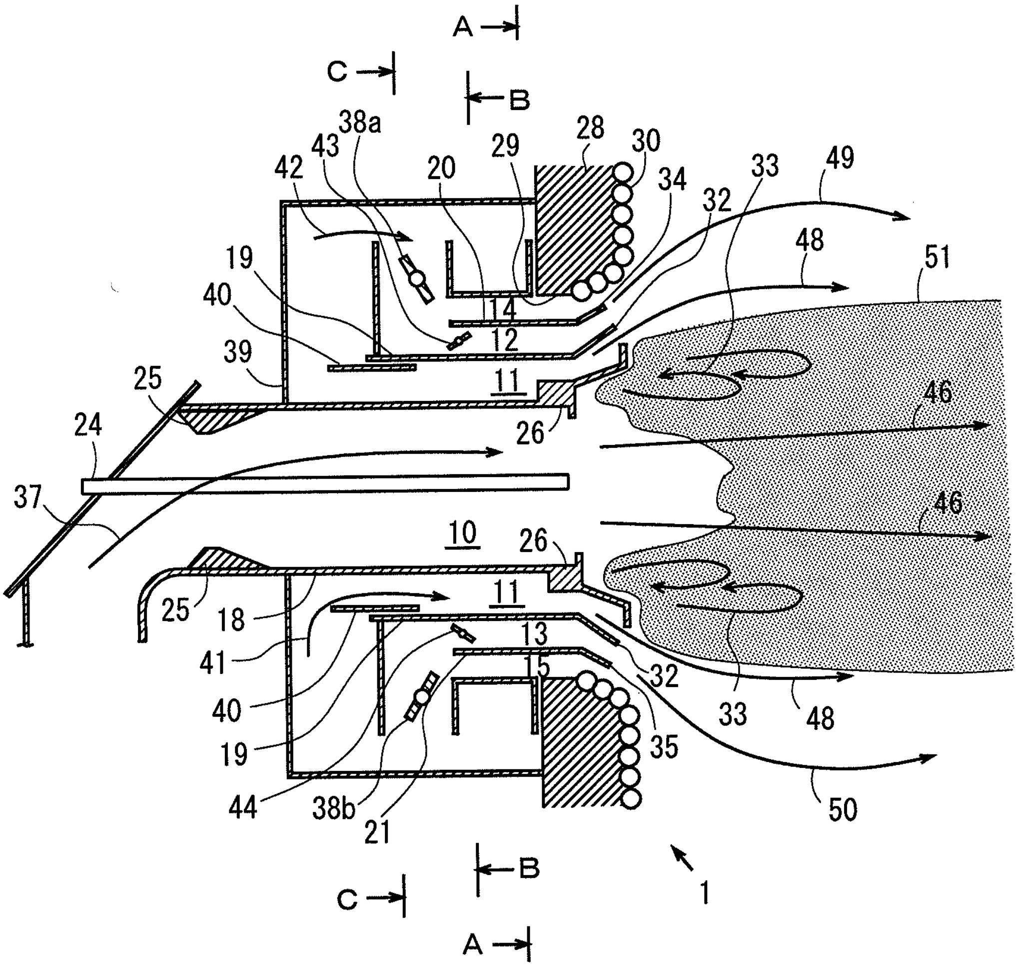
9. The solid fuel burner according to Claim 1, wherein at an outlet of the fuel nozzle, obstacles which obstruct a fuel jet flow flowing in the fuel nozzle or an air flow flowing in the air nozzle close to the fuel nozzle are provided.

10. A combustion apparatus comprising a furnace having the solid fuel burner according to Claim 1 installed on a furnace wall, wherein
the combustion apparatus includes a control device which changes an air flow rate flowing in at least one of the plurality of regions of the air nozzle of the solid fuel burner, whose inside is divided by obstacles in the circumferential direction of the fuel nozzle into the plurality of regions, based on a combustion gas

temperature at the furnace outlet, a temperature of a heat transfer tube installed on a furnace wall surface, a temperature of a fluid flowing in the heat transfer tube, temperatures of heat transfer tubes provided in the furnace and a flue on the downstream side of the furnace or temperatures of fluids flowing in the heat transfer tubes.

11. A method of operating a combustion apparatus comprising a furnace including the solid fuel burner according to Claim 1 installed on a furnace wall, wherein
a deviation is generated in the circumferential direction of the fuel nozzle in an air volume flowing in the air nozzle of the solid fuel burner based on a combustion gas temperature at the furnace outlet, temperatures of heat transfer tubes installed on a furnace wall surface, a temperature of a fluid flowing in the heat transfer tube, temperatures of heat transfer tubes provided in the furnace and a flue on the downstream side of the furnace or temperatures of fluids flowing in the heat transfer tubes.

F I G. 1



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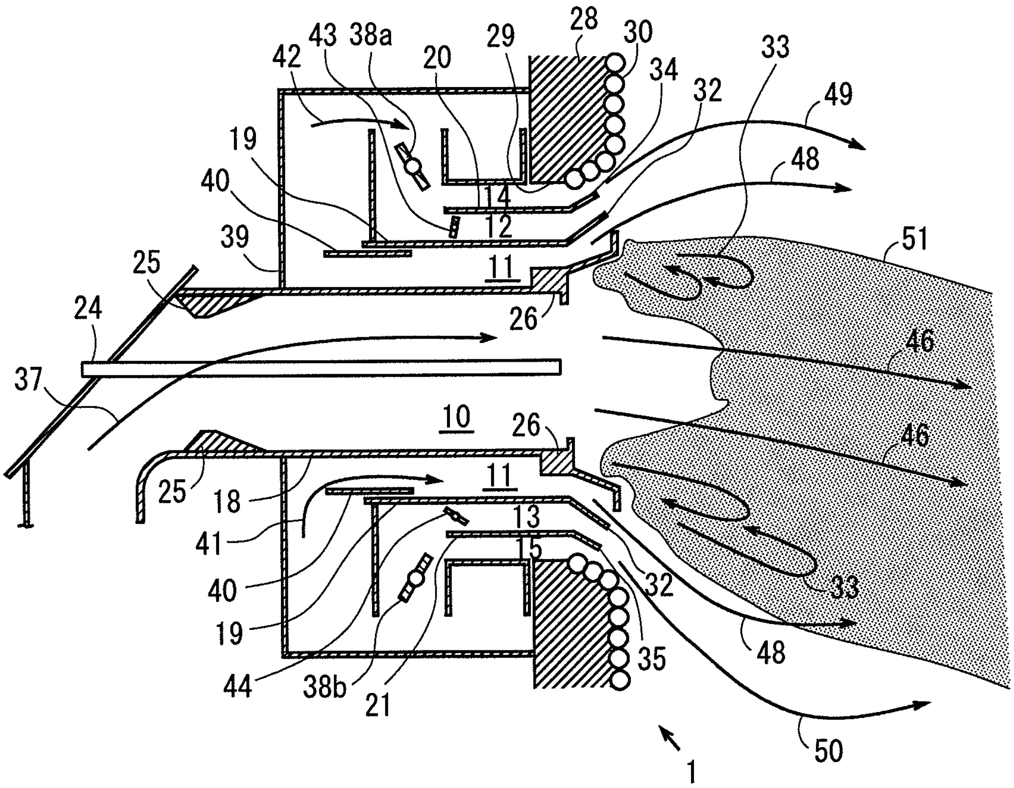
F I G. 2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F I G. 3

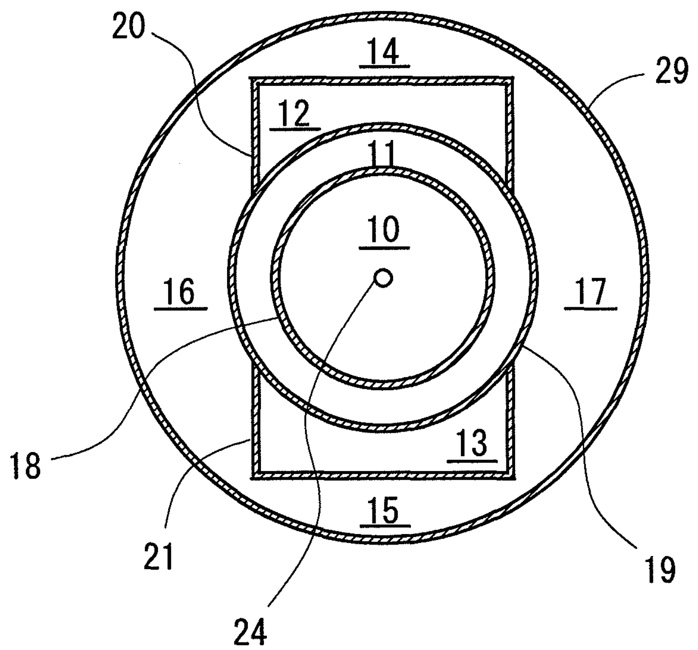
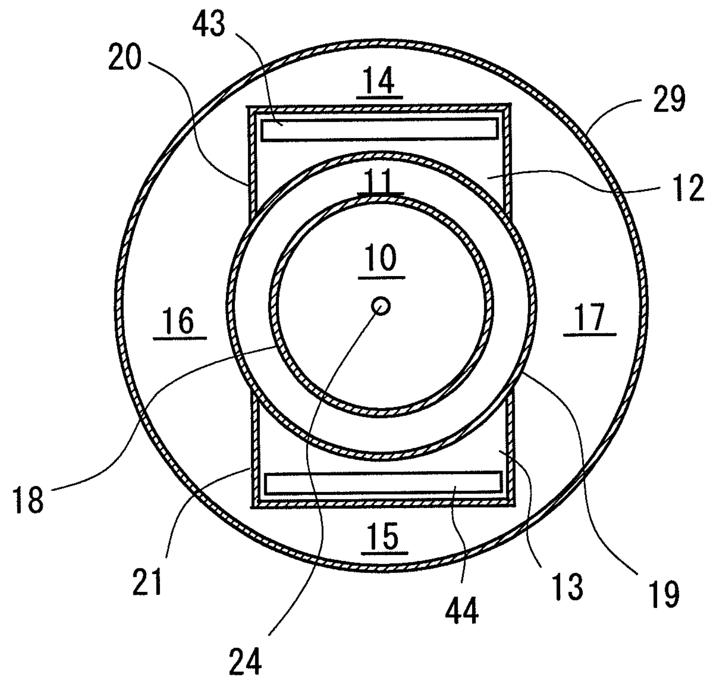
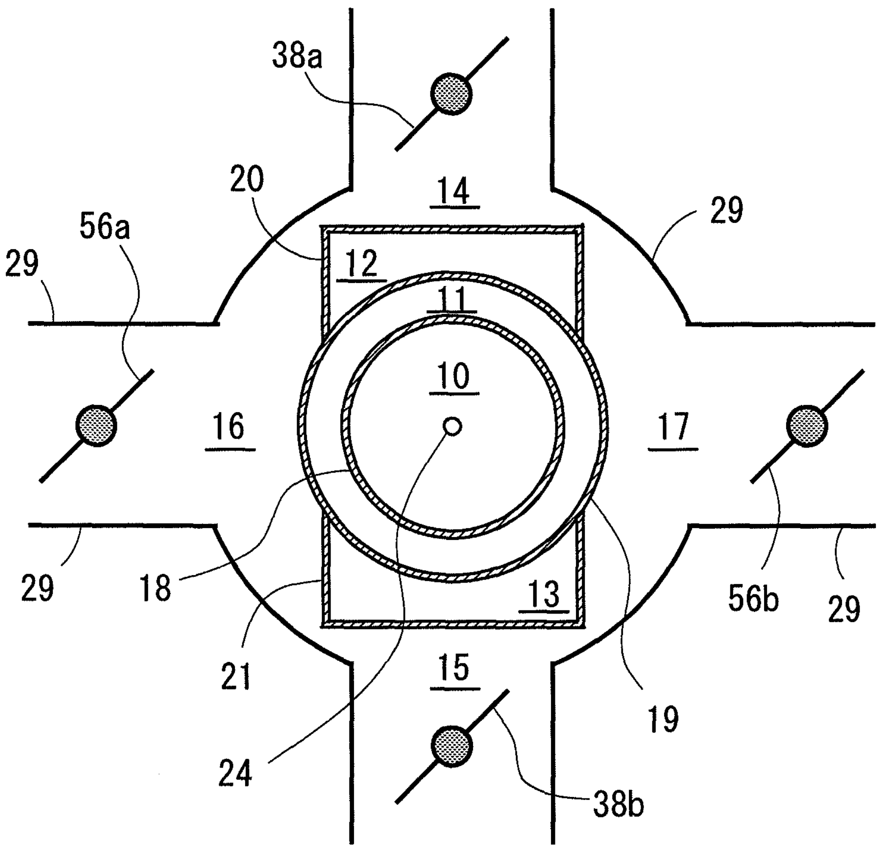


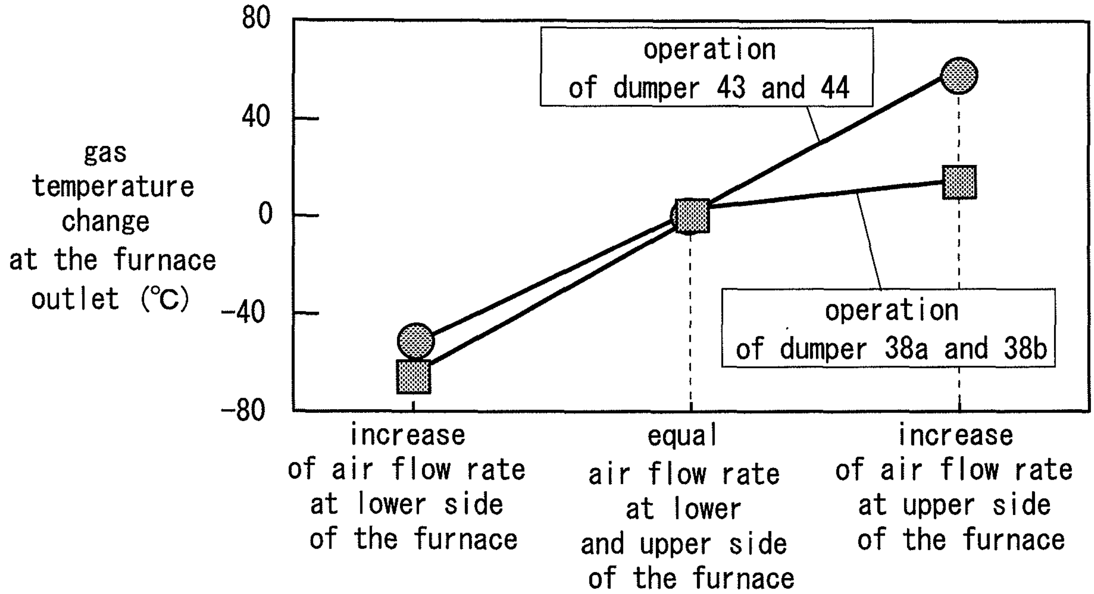
FIG. 4



F I G. 5

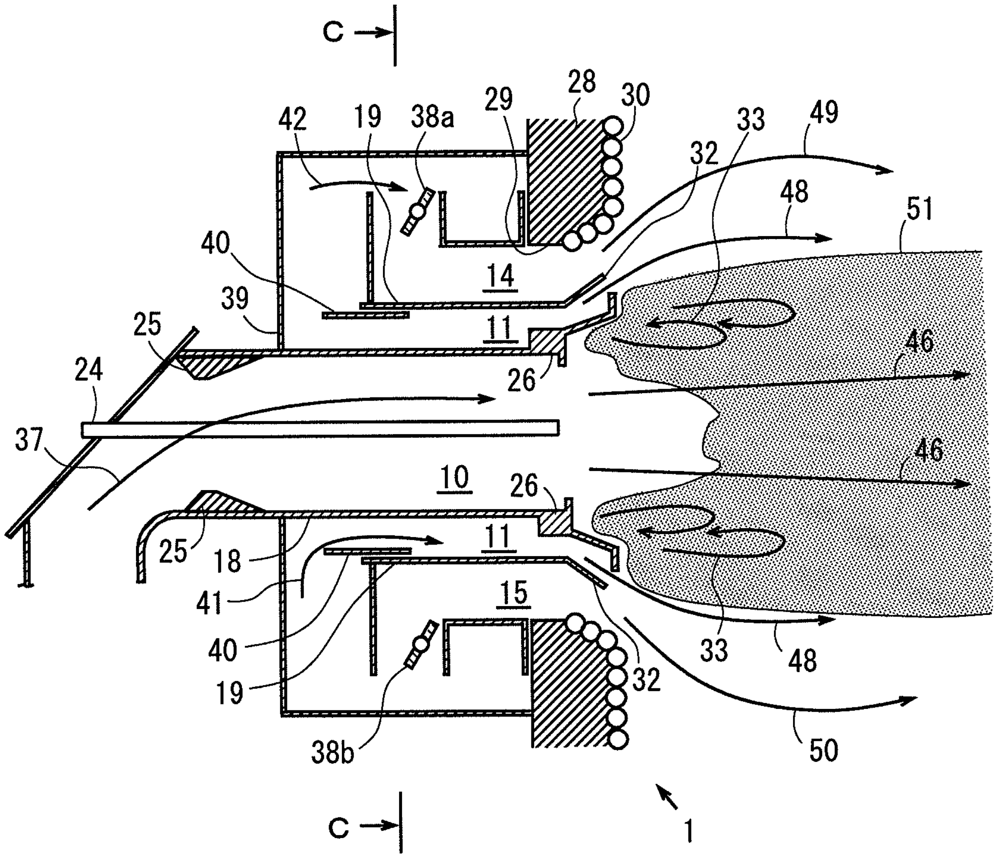


F I G. 6



80
40
0
-40
-80
gas temperature change at the furnace outlet (℃)
operation of dumper 43 and 44
operation of dumper 38a and 38b
increase of air flow rate at lower side of the furnace
equal air flow rate at lower and upper side of the furnace
increase of air flow rate at upper side of the furnace

FIG. 7


C
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38a
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38b
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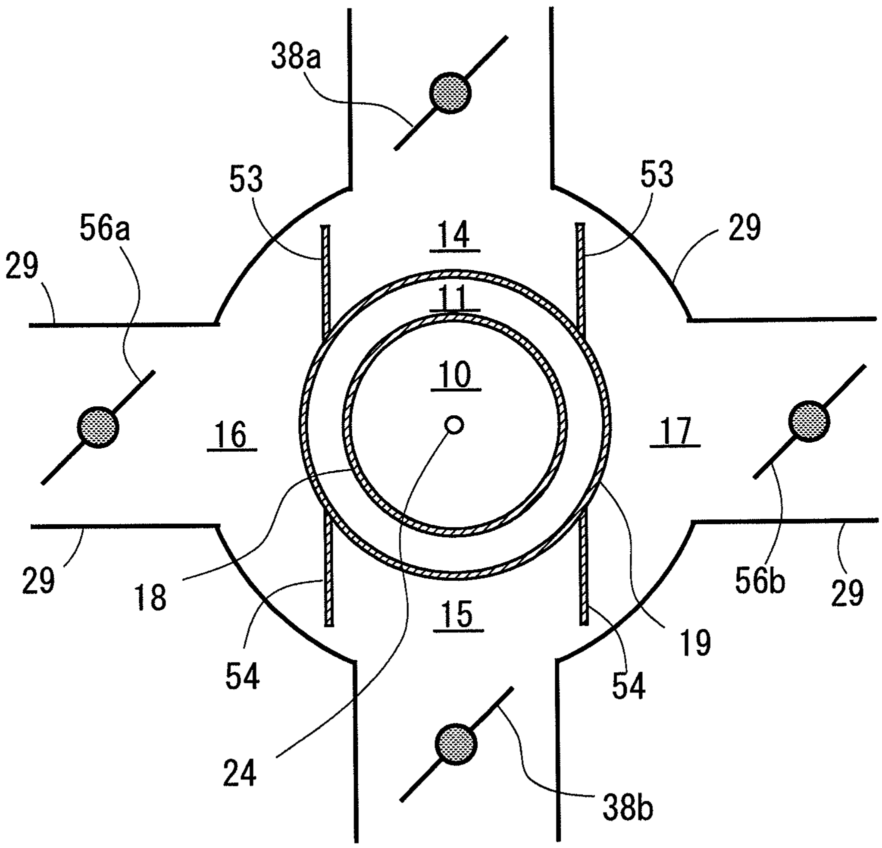
F I G. 8



F I G. 9

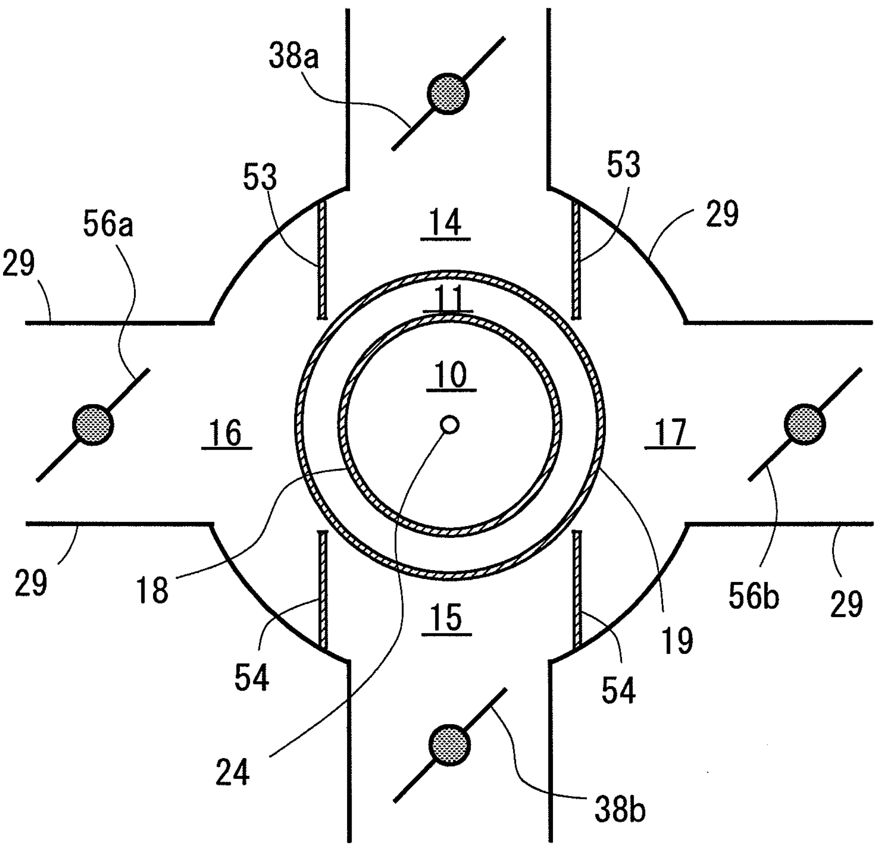
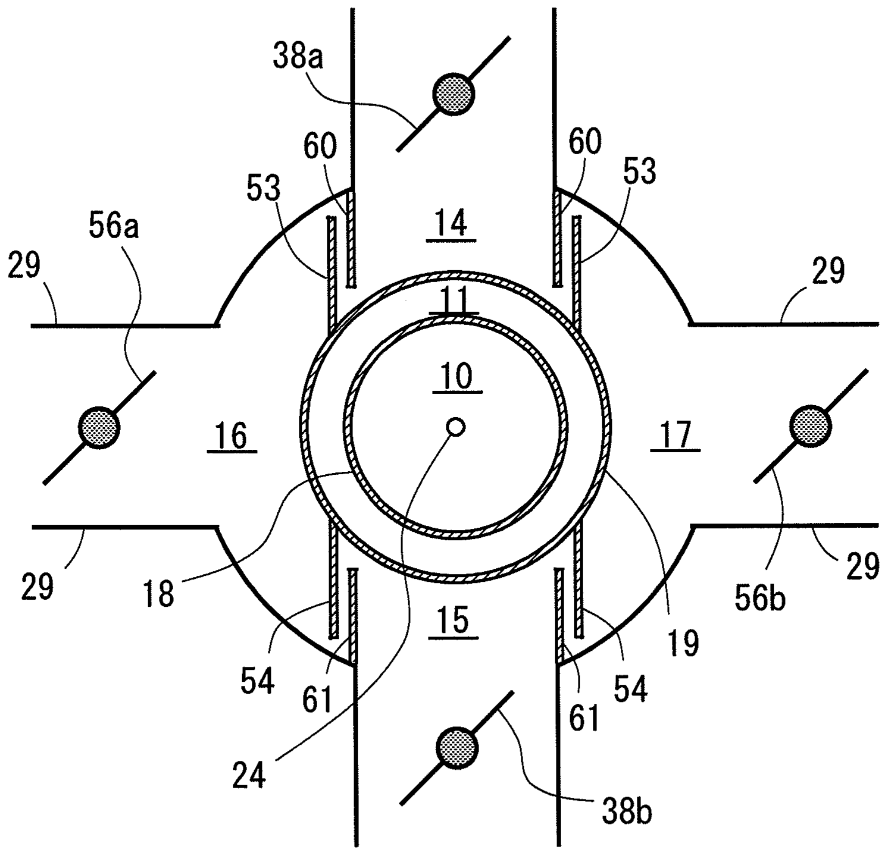


FIG. 10


38a
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60
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56a
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16
17
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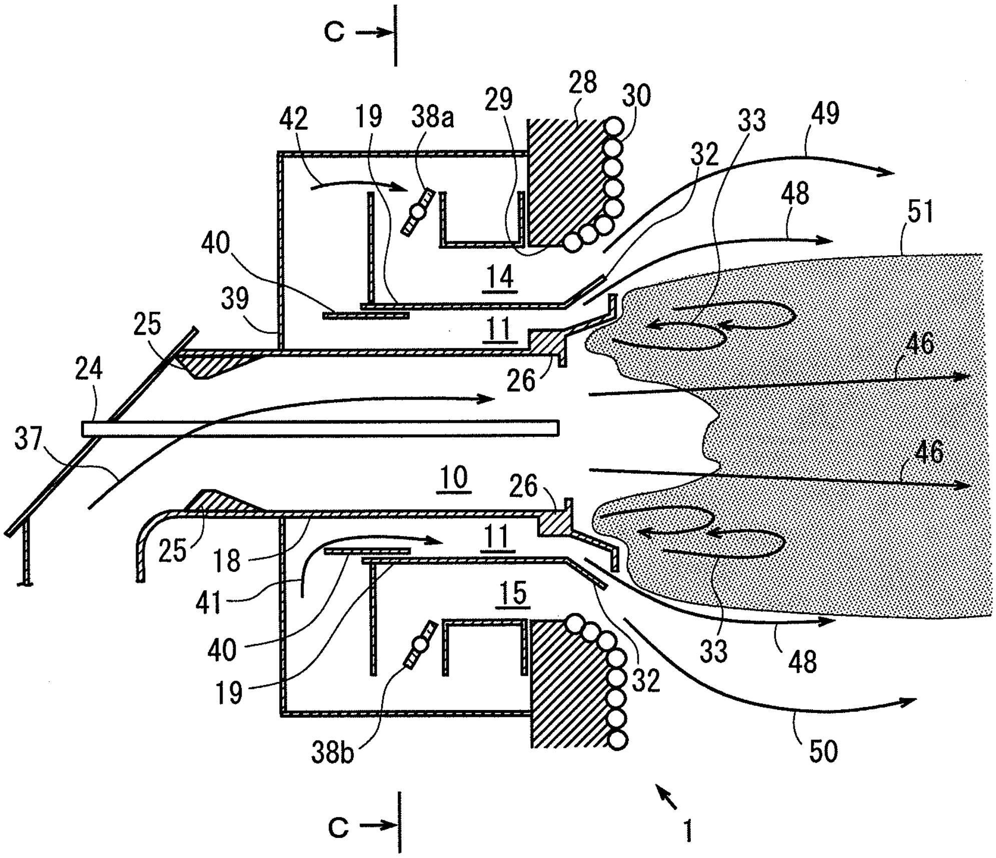
56b
15
54
54
61
61
24
38b

FIG. 11


C
42
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38a
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38b
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C
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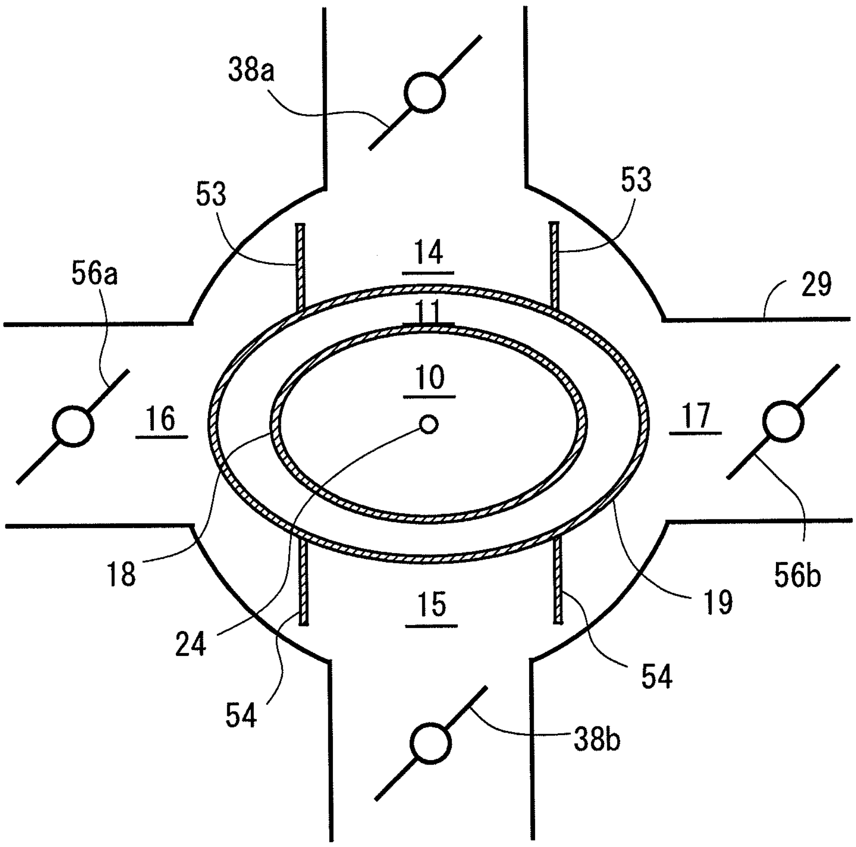
F I G. 1 2



F I G. 1 3

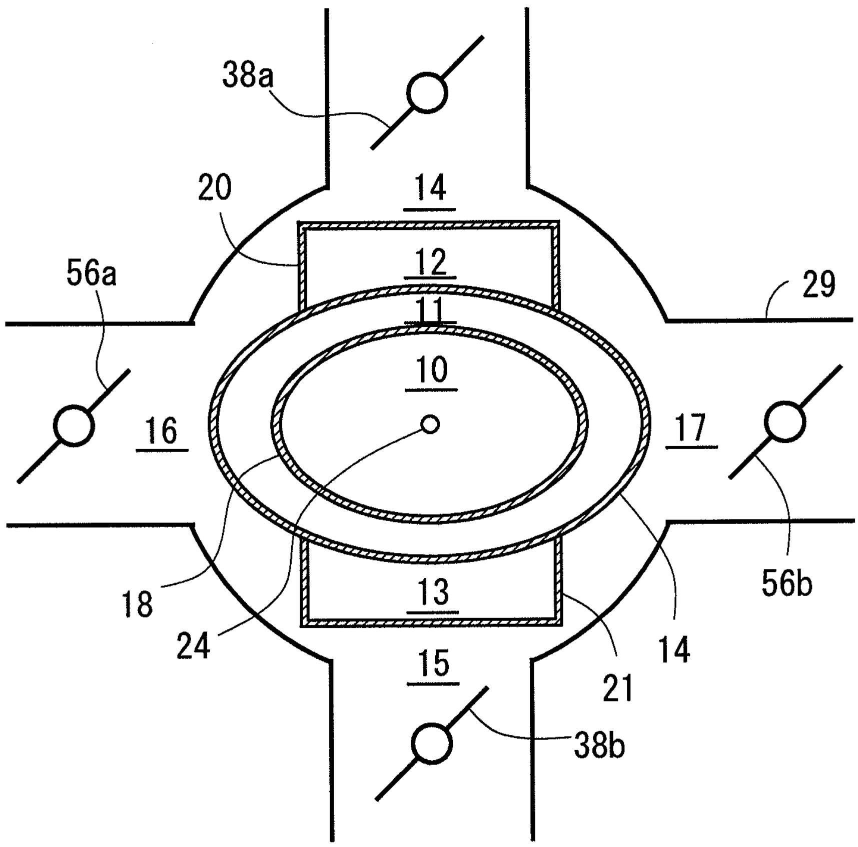
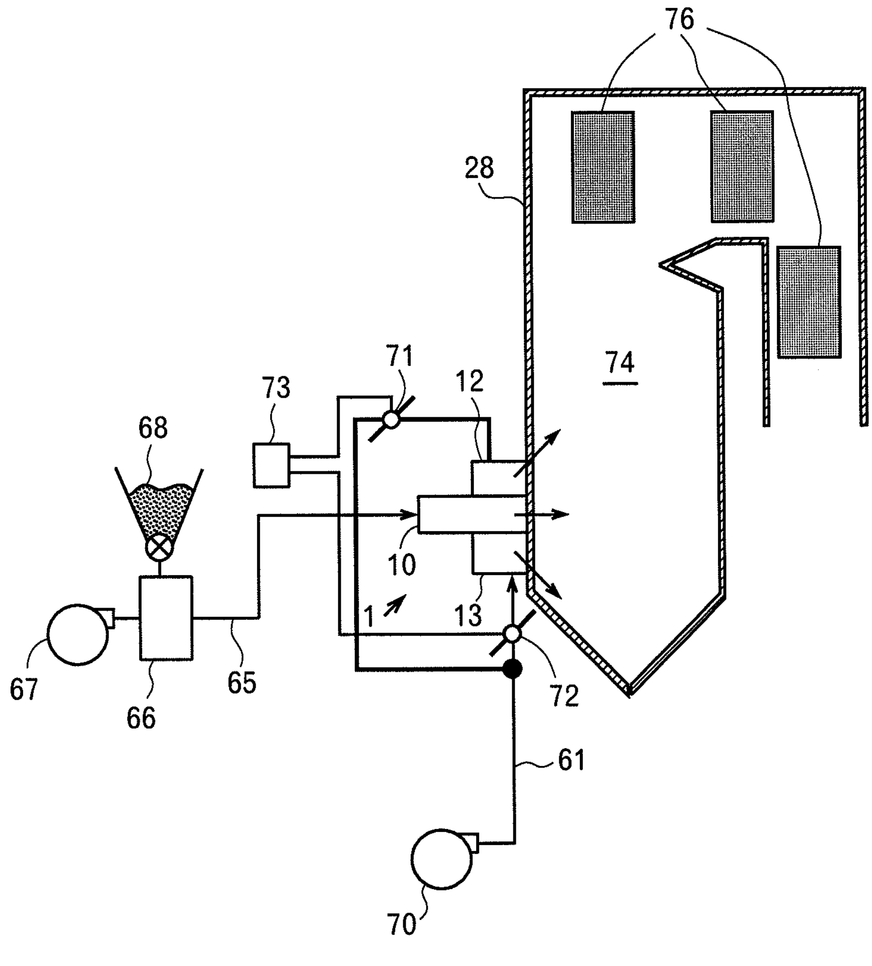


FIG. 14



INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2009/001573

A. CLASSIFICATION OF SUBJECT MATTER
F23D1/00(2006.01)i, *F23C99/00*(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
F23D1/00, F23C99/00

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Jitsuyo Shinan Koho	1922-1996	Jitsuyo Shinan Toroku Koho	1996-2009
Kokai Jitsuyo Shinan Koho	1971-2009	Toroku Jitsuyo Shinan Koho	1994-2009

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 2005-273973 A (Hitachi, Ltd.), 06 October, 2005 (06.10.05), Page 6, lines 17 to 45; Figs. 1 to 2 & US 2005/0211142 A1 & EP 1580486 A1 & CA 2496644 A1 & KR 2006/0042080 A & CN 1673620 A	1,5-6,8-11
Y	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 184834/1984(Laid-open No. 101226/1986) (Toyota Motor Corp.), 27 June, 1986 (27.06.86), Page 6, line 3 to page 10, line 6; Figs. 1 to 2 (Family: none)	1,5-6,8-11

☒ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:
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"E" earlier application or patent but published on or after the international filing date
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"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
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"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
05 June, 2009 (05.06.09)	16 June, 2009 (16.06.09)
Name and mailing address of the ISA/ Japanese Patent Office	Authorized officer
Facsimile No.	Telephone No.

Form PCT/ISA/210 (second sheet) (April 2007)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2009/001573

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 2000-356309 A (Babcock-Hitachi Kabushiki Kaisha), 26 December, 2000 (26.12.00), Column 4, line 16 to column 6, line 1; Fig. 5 (Family: none)	1-11
A	JP 09-021507 A (Hitachi, Ltd.), 21 January, 1997 (21.01.97), Full text; all drawings (Family: none)	1-11
A	JP 63-140208 A (Hitachi, Ltd.), 11 June, 1988 (11.06.88), Full text; all drawings (Family: none)	1-11

Form PCT/ISA/210 (continuation of second sheet) (April 2007)

REFERENCES CITED IN THE DESCRIPTION

Patent documents cited in the description

- US 6439136 B **[0005]**