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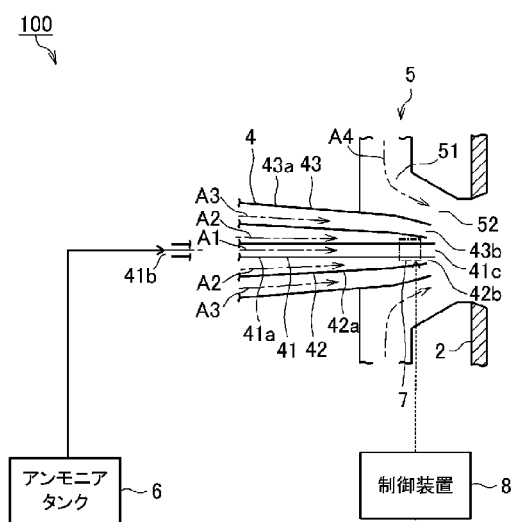


FIG. 2

6 Ammonia tank
8 Control device

(57) Abstract: A combustion device (100) comprises: an ammonia injection nozzle (41) with an injection port (41c) facing the interior space of a furnace (2); a pulverized coal injection nozzle (43) with an injection port (43b) facing the interior space of the furnace (2); an adjustment mechanism (7) that adjusts the injection velocity of ammonia from the ammonia injection nozzle (41); and a control device (8) that controls the operation of the adjustment mechanism (7) so that the injection velocity of ammonia from the ammonia injection nozzle (41) is faster than the injection velocity of pulverized coal from the pulverized coal injection nozzle (43).

(57) 要約: 燃烧装置 (100) は、火炉 (2) の内部空間に噴射口 (41c) が臨むアンモニア噴射ノズル (41) と、火炉 (2) の内部空間に噴射口 (43b) が臨む微粉炭噴射ノズル (43) と、アンモニア噴射ノズル (41) からのアンモニアの噴射流速を調整する調整機構 (7) と、アンモニア噴射ノズル (41) からのアンモニアの噴射流速が微粉炭噴射ノズル (43) からの微粉炭の噴射流速よりも速くなるように、調整機構 (7) の動作を制御する制御装置 (8) と、を備える。

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Description

Title: COMBUSTION DEVICE AND BOILER

Technical Field

[0001]

The present disclosure relates to a combustion device and a boiler. The present application claims the benefit of priority based on Japanese Patent Application No. 2021-169141 filed on October 14, 2021, the content of which is incorporated herein.

Background Art

[0002]

In a burner provided in a furnace such as a boiler, there is a burner having an ammonia injection nozzle that injects ammonia as fuel. By using ammonia as fuel, carbon dioxide emission is reduced. For example, Patent Literature 1 discloses a burner that performs co-firing of pulverized coal and ammonia as fuel.

Citation List

Patent Literature

[0003]

Patent Literature 1: JP 2019-086189 A

Summary

[0004]

In a burner that performs co-firing of pulverized coal and ammonia as fuel, nitrogen oxides (hereinafter, also referred to as NO_x) are generated and reduced in a flame formed in front of the burner. Depending on the operating conditions, the reduction of NO_x is not sufficiently performed, and the amount of NO_x emission may increase. Therefore, a new

proposal for suppressing NOx emission is desired.

[0005]

According to one aspect of the present disclosure, there is provided a combustion device and a boiler capable of suppressing emission of nitrogen oxides (NOx).

[0006]

According to one aspect, a combustion device according to the present disclosure includes: an ammonia injection nozzle having an injection port facing an internal space of a furnace; a pulverized coal injection nozzle having an injection port facing the internal space of the furnace; an adjustment mechanism that adjusts an injection flow rate of ammonia from the ammonia injection nozzle; and a control device that controls an operation of the adjustment mechanism in such a manner that the injection flow rate of ammonia from the ammonia injection nozzle is higher than an injection flow rate of pulverized coal from the pulverized coal injection nozzle.

[0007]

The adjustment mechanism may include a mechanism that adjusts an opening area of the injection port of the ammonia injection nozzle.

[0008]

The ammonia injection nozzle may include a plurality of ammonia flow paths, and the adjustment mechanism may include a mechanism that adjusts the number of ammonia flow paths through which ammonia flows among the plurality of ammonia flow paths.

[0009]

In one aspect, the boiler of the present disclosure includes the

combustion device described above.

[0010]

According to the present disclosure, it is possible to suppress emission of nitrogen oxides (NO_x).

[0010a]

According to an aspect of the present invention, there is provided a combustion device comprising: an ammonia injection nozzle having an injection port facing an internal space of a furnace; an air injection nozzle having an injection port facing the internal space of the furnace and disposed in such a manner as to surround the ammonia injection nozzle; a pulverized coal injection nozzle having an injection port facing the internal space of the furnace and disposed in such a manner as to surround the air injection nozzle; an adjustment mechanism that adjusts an injection flow speed of ammonia from the ammonia injection nozzle; and a control device that controls an operation of the adjustment mechanism in such a manner that the injection flow speed of ammonia from the ammonia injection nozzle is higher than an injection flow speed of pulverized coal from the pulverized coal injection nozzle; Wherein the control device that controls the operation of the adjustment mechanism in such a manner that the injection flow speed of ammonia from the ammonia injection nozzle is equal to a rate at which in a flame formed by a burner having the ammonia injection nozzle and the pulverized coal injection nozzle, a decomposition region of ammonia located on a center side of the flame and a reduction region of NO_x is positioned on a distal end side of the flame with respect to the decomposition region are formed.

Brief Description of Drawings

[0011]

Fig. 1 is a schematic diagram illustrating a boiler according to the present embodiment.

Fig. 2 is a schematic diagram illustrating a combustion device according to the present embodiment.

Fig. 3 is a schematic diagram illustrating an adjustment mechanism according to the present embodiment.

Fig. 4 is a schematic diagram illustrating a state in which the opening area of an injection port of an ammonia
5 injection nozzle according to the present embodiment is smaller than that in the example of Fig. 3.

Fig. 5 is a flowchart illustrating an example of a flow of processing performed by a control device according to the present embodiment.

10 Fig. 6 is a diagram for explaining a flame formed by the combustion device according to the present embodiment.

Fig. 7 is a diagram for explaining a flame formed by a combustion device according to a comparative example.

15 Fig. 8 is a schematic diagram illustrating a combustion device according to a modification.

Fig. 9 is a cross-sectional view illustrating the inside of an ammonia injection nozzle according to a modification.

Description of Embodiments

20 [0012]

Embodiments of the present disclosure will be described below by referring to the accompanying drawings. Dimensions, materials, other specific numerical values, and the like
illustrated in the embodiments are merely an example for
25 facilitating understanding, and the present disclosure is not limited thereto unless otherwise specified. Note that, in the present specification and the drawings, components having

substantially the same function and structure are denoted by the same symbol, and redundant explanations are omitted. Illustration of components not directly related to the present disclosure is omitted.

5 [0013]

Fig. 1 is a schematic diagram illustrating a boiler 1 according to the present embodiment. As illustrated in Fig. 1, the boiler 1 includes a furnace 2, a flue 3, and burners 4.

10 [0014]

In the furnace 2, fuel is burnt to generate combustion heat. The furnace 2 has a tubular shape such as a rectangular tubular shape extending in the vertical direction. In the furnace 2, high-temperature combustion gas is generated by combustion of fuel. A bottom portion of the furnace 2 includes a discharge port 2a for discharging ash generated by combustion of fuel to the outside.

[0015]

The flue 3 is a passage for guiding combustion gas generated in the furnace 2 to the outside as exhaust gas. The flue 3 is connected with an upper part of the furnace 2. The flue 3 has a horizontal flue 3a and a rear flue 3b. The horizontal flue 3a extends horizontally from the upper part of the furnace 2. The rear flue 3b extends downward from an end of the horizontal flue 3a.

[0016]

The boiler 1 includes a superheater (not illustrated)

installed above or on the furnace 2. In the superheater, heat is exchanged between combustion heat generated in the furnace 2 and water. As a result of this, water vapor is generated. The boiler 1 may also include various devices
5 such as a reheater, a coal economizer, and an air preheater not illustrated in Fig. 1.

[0017]

The burners 4 are provided at a lower wall portion of the furnace 2. In the furnace 2, a plurality of burners 4 is
10 provided at intervals in the circumferential direction of the furnace 2. Although not illustrated in Fig. 1, the plurality of burners 4 is provided at intervals also in the vertical direction which is the extending direction of the furnace 2. The burners 4 inject ammonia and pulverized coal as fuel into
15 the furnace 2. The fuel injected from the burners 4 burns to form a flame F in the furnace 2. The furnace 2 is provided with an ignition device (not illustrated) that ignites the fuel injected from the burners 4.

[0018]

20 Fig. 2 is a schematic diagram illustrating a combustion device 100 according to the present embodiment. As illustrated in Fig. 2, the combustion device 100 includes a burner 4, an air supply unit 5, an ammonia tank 6, an adjustment mechanism 7, and a control device 8.

25 [0019]

The burner 4 is attached to a wall portion of the furnace 2 outside the furnace 2. The burner 4 includes an ammonia

injection nozzle 41, an air injection nozzle 42, and a pulverized coal injection nozzle 43. The ammonia injection nozzle 41 is a nozzle that injects ammonia. The air injection nozzle 42 is a nozzle that injects air for combustion. The pulverized coal injection nozzle 43 is a nozzle that injects pulverized coal.

[0020]

The ammonia injection nozzle 41, the air injection nozzle 42, and the pulverized coal injection nozzle 43 each have a cylindrical shape. The air injection nozzle 42 is disposed coaxially with the ammonia injection nozzle 41 in such a manner as to surround the ammonia injection nozzle 41. The pulverized coal injection nozzle 43 is disposed coaxially with the air injection nozzle 42 in such a manner as to surround the air injection nozzle 42. The ammonia injection nozzle 41, the air injection nozzle 42, and the pulverized coal injection nozzle 43 form a triple cylindrical structure. The central axes of the ammonia injection nozzle 41, the air injection nozzle 42, and the pulverized coal injection nozzle 43 intersect with the wall portion of the furnace 2.

Specifically, the central axes of the ammonia injection nozzle 41, the air injection nozzle 42, and the pulverized coal injection nozzle 43 are substantially orthogonal to the wall portion of the furnace 2.

[0021]

Hereinafter, the radial direction of the burner 4, the axial direction of the burner 4, and the circumferential

direction of the burner 4 are also simply referred to as the radial direction, the axial direction, and the circumferential direction, respectively. The furnace 2 side (right side in Fig. 2) of the burner 4 is referred to as a distal end side, and the opposite side (left side in Fig. 2) of the burner 4 to the furnace 2 side is referred to as a rear end side.

[0022]

The ammonia injection nozzle 41 includes a main body 41a, a supply port 41b, and an injection port 41c. The main body 41a has a cylindrical shape. The main body 41a extends along the central axis of the burner 4. The wall thickness, the inner diameter, and the outer diameter of the main body 41a are substantially constant regardless of the axial position. However, the wall thickness, the inner diameter, and the outer diameter of the main body 41a may vary depending on the axial position. The supply port 41b that is an opening is included at the rear end of the main body 41a. The supply port 41b is connected with the ammonia tank 6. The injection port 41c which is an opening is included at the distal end of the main body 41a. The injection port 41c faces the internal space of the furnace 2. That is, the injection port 41c faces the internal space of the furnace 2.

[0023]

Ammonia is supplied from the ammonia tank 6 into the main body 41a through the supply port 41b. As indicated by an arrow A1, the ammonia supplied into the main body 41a flows

in the main body 41a. The ammonia that has passed through the inside of the main body 41a is injected from the injection port 41c towards the internal space of the furnace 2. In this manner, the ammonia injection nozzle 41 is
5 included in such a manner as to face the internal space of the furnace 2.

[0024]

The ammonia tank 6 stores ammonia in liquid form. The ammonia stored in the ammonia tank 6 is vaporized by a
10 vaporizer. The vaporized ammonia is supplied to the ammonia injection nozzle 41.

[0025]

The air injection nozzle 42 includes a main body 42a and an injection port 42b. The main body 42a has a cylindrical
15 shape. The main body 42a is disposed coaxially with the main body 41a of the ammonia injection nozzle 41 in such a manner as to surround the main body 41a. The main body 42a has a tapered shape tapered towards the distal end side. A supply port (not illustrated) is included at the rear portion of the
20 main body 42a.

[0026]

The supply port of the air injection nozzle 42 is connected with an air supply source (not illustrated). For example, the supply port of the air injection nozzle 42 is
25 exposed to the atmosphere as the air supply source. The injection port 42b which is an opening is included at the distal end of the main body 42a. On a radially inner side of

the distal end of the main body 42a, the distal end of the main body 41a of the ammonia injection nozzle 41 is positioned. The injection port 42b is an annular opening between the distal end of the main body 42a and the distal
5 end of the main body 41a of the ammonia injection nozzle 41. The injection port 42b faces the internal space of the furnace 2. That is, the injection port 42b faces the internal space of the furnace 2.

[0027]

10 The air is supplied from the air supply source into the main body 42a via the supply port (not illustrated). As indicated by an arrow A2, the air supplied into the main body 42a flows in a space between an inner peripheral portion of the main body 42a and an outer peripheral portion of the main
15 body 41a of the ammonia injection nozzle 41. The air having passed through the inside of the main body 42a is injected from the injection port 42b towards the internal space of the furnace 2. In this manner, the air injection nozzle 42 is included in such a manner as to face the internal space of
20 the furnace 2.

[0028]

The pulverized coal injection nozzle 43 includes a main body 43a and an injection port 43b. The main body 43a has a cylindrical shape. The main body 43a is disposed coaxially
25 with the main body 42a of the air injection nozzle 42 in such a manner as to surround the main body 42a. The main body 43a has a tapered shape tapered towards the distal end side. A

supply port (not illustrated) is provided at the rear portion of the main body 43a.

[0029]

The supply port of the pulverized coal injection nozzle 5 43 is connected with a pulverized coal supply source (not illustrated). The injection port 43b which is an opening is included at the distal end of the main body 43a. The axial position of the distal end of the main body 43a substantially coincides with the axial position of the distal end of the 10 main body 42a of the air injection nozzle 42. The injection port 43b is an annular opening between the distal end of the main body 43a and the distal end of the main body 42a of the air injection nozzle 42. The injection port 43b faces the internal space of the furnace 2. That is, the injection port 15 43b faces the internal space of the furnace 2.

[0030]

The pulverized coal is supplied into the main body 43a from the pulverized coal supply source via the supply port (not illustrated) together with air for conveying the 20 pulverized coal. As indicated by an arrow A3, the pulverized coal supplied into the main body 43a flows, together with the air, in the space between an inner peripheral portion of the main body 43a and an outer peripheral portion of the main body 42a of the air injection nozzle 42. The pulverized coal 25 having passed through the inside of the main body 43a is injected from the injection port 43b towards the internal space of the furnace 2. In this manner, the pulverized coal

injection nozzle 43 is included in such a manner as to face the internal space of the furnace 2.

[0031]

The air supply unit 5 supplies air for combustion to the
5 flame F formed by the burner 4 from radially outside. The air supply unit 5 is disposed in such a manner as to cover a space between the distal end of the burner 4 and the furnace 2. A flow path 51 through which air flows is formed in the air supply unit 5. The flow path 51 is formed in a
10 cylindrical shape coaxial with the burner 4. The flow path 51 is connected with an air supply source (not illustrated). An injection port 52 is formed at an end of the flow path 51 on the furnace 2 side.

[0032]

15 As indicated by an arrow A4, air supplied from the air supply source to the air supply unit 5 passes through the flow path 51 and is injected from the injection port 52 towards the internal space of the furnace 2. The injection port 52 faces the internal space of the furnace 2. That is,
20 the injection port 52 faces the internal space of the furnace 2. In this manner, the air supply unit 5 is included in such a manner as to face the internal space of the furnace 2. The air injected from the injection port 52 of the air supply unit 5 advances towards the internal space of the furnace 2
25 while swirling in the circumferential direction.

[0033]

The adjustment mechanism 7 is a mechanism for adjusting

the injection flow rate of ammonia from the ammonia injection nozzle 41. The injection flow rate of ammonia is the flow rate of ammonia injected from the injection port 41c of the ammonia injection nozzle 41. In the present embodiment, the
5 adjustment mechanism 7 adjusts the injection flow rate of ammonia from the ammonia injection nozzle 41 by adjusting the opening area of the injection port 41c of the ammonia injection nozzle 41. Details of the adjustment mechanism 7 will be described with reference to Fig. 3.

10 [0034]

Fig. 3 is a schematic diagram illustrating the adjustment mechanism 7 according to the present embodiment. As illustrated in Fig. 3, a variable unit 41d is provided at the distal end of the ammonia injection nozzle 41. As the
15 variable unit 41d changes its shape, the opening area of the injection port 41c changes. For example, the variable unit 41d includes a plurality of members spaced apart in the circumferential direction, and the shape thereof can be changed in such a manner that each of the members is in an
20 inclined attitude in which a distal end is located radially inward relative to a rear end. As such a variable unit 41d, for example, a structure similar to that of the convergent-divergent nozzles can be adopted.

[0035]

25 The adjustment mechanism 7 includes a drive device 71. The drive device 71 changes the shape of the variable unit 41d of the ammonia injection nozzle 41. For example, the

drive device 71 is provided at the rear end of the variable unit 41d and includes a power source such as a motor that generates power. Then, the drive device 71 can change the attitude of the variable unit 41d by rotating the variable unit 41d about the rear end of the variable unit 41d. The adjustment mechanism 7 can adjust the opening area of the injection port 41c of the ammonia injection nozzle 41 by changing the shape of the variable unit 41d of the ammonia injection nozzle 41 by the drive device 71.

10 [0036]

Fig. 4 is a schematic diagram illustrating a state in which the opening area of the injection port 41c of the ammonia injection nozzle 41 according to the present embodiment is smaller than that in the example of Fig. 3. In the example of Fig. 4, as compared with the example of Fig. 3, the shape of the variable unit 41d is changed in such a manner that the radial position of the distal end of the variable unit 41d moves radially inward. Accordingly, the shape of the variable unit 41d is tapered towards the distal end side. For example, the shape of the variable unit 41d in Fig. 4 is a truncated cone shape. Therefore, the opening area of the injection port 41c of the ammonia injection nozzle 41 is reduced.

[0037]

25 As the opening area of the injection port 41c of the ammonia injection nozzle 41 decreases, the flow rate of ammonia injected from the injection port 41c increases.

Therefore, the adjustment mechanism 7 can adjust the injection flow rate of ammonia from the ammonia injection nozzle 41 by adjusting the opening area of the injection port 41c of the ammonia injection nozzle 41. As described above, the adjustment mechanism 7 appropriately achieves adjustment of the injection flow rate of ammonia.

[0038]

The control device 8 in Fig. 2 includes a central processing unit (CPU), a ROM in which a program and the like are stored, a RAM as a work area, and others and controls the entire combustion device 100. In particular, the control device 8 controls the operation of the adjustment mechanism 7. Specifically, the control device 8 can adjust the opening area of the injection port 41c of the ammonia injection nozzle 41 by controlling the drive device 71 of the adjustment mechanism 7 to adjust the injection flow rate of ammonia from the ammonia injection nozzle 41.

[0039]

Fig. 5 is a flowchart illustrating an example of a flow of processing performed by the control device 8 according to the present embodiment. The processing flow illustrated in Fig. 5 is repeatedly executed at preset time intervals, for example. As will be described later, the processing example of Fig. 5 is merely an example, and the processing performed by the control device 8 is not limited to this example.

[0040]

When the processing flow illustrated in Fig. 5 starts, in

step S101, the control device 8 acquires the injection flow rate of pulverized coal from the pulverized coal injection nozzle 43. The injection flow rate of pulverized coal is the flow rate of the pulverized coal injected from the injection port 43b of the pulverized coal injection nozzle 43.

[0041]

The supply amount of air for conveyance supplied to the pulverized coal injection nozzle 43 varies depending on the required combustion amount in the furnace 2. Accordingly, the injection flow rate of the pulverized coal varies depending on the required combustion amount in the furnace 2. For example, the injection flow rate of pulverized coal increases as the required combustion amount in the furnace 2 increases. The required combustion amount in the furnace 2 correlates with a required load or a required power generation amount of the boiler 1.

[0042]

The control device 8 acquires the supply amount of air for conveyance, for example, a device that controls the supply amount of the air for conveyance supplied to the pulverized coal injection nozzle 43. Then, the control device 8 can acquire the injection flow rate of the pulverized coal on the basis of the supply amount of the air for conveyance. The control device 8 may control the supply amount of air for control device supplied to the pulverized coal injection nozzle 43.

[0043]

After step S101, in step S102, the control device 8 controls the adjustment mechanism 7 in such a manner that the injection flow rate of ammonia is higher than the injection flow rate of pulverized coal. For example, the control
5 device 8 controls the drive device 71 of the adjustment mechanism 7 in such a manner that the opening area of the injection port 41c of the ammonia injection nozzle 41 varies depending on the injection flow rate of pulverized coal. This makes it possible to make the injection flow rate of
10 ammonia to be higher than the injection flow rate of pulverized coal.

[0044]

It is preferable that the control device 8 controls the adjustment mechanism 7 in consideration of a parameter other
15 than the opening area of the injection port 41c among parameters that affect the injection flow rate of ammonia. For example, the supply amount of ammonia to the ammonia injection nozzle 41 can vary depending on the required combustion amount in the furnace 2. Therefore, the control
20 device 8 preferably controls the adjustment mechanism 7 on the basis of the supply amount of ammonia to the ammonia injection nozzle 41 in addition to the injection flow rate of pulverized coal. As a result, it is more appropriately achieved that the injection flow rate of ammonia is made
25 higher than the injection flow rate of pulverized coal.

[0045]

In the above description, the example has been described

in which the opening area of the injection port 41c of the ammonia injection nozzle 41 is varied depending on the injection flow rate of pulverized coal. However, the control device 8 may cause the opening area of the injection port 41c of the ammonia injection nozzle 41 to vary depending on a parameter other than the injection flow rate of pulverized coal. For example, the control device 8 cause the opening area of the injection port 41c of the ammonia injection nozzle 41 to vary depending on the required combustion amount in the furnace 2, the required load of the boiler 1, or the required power generation amount of the boiler 1.

[0046]

As described above, in the combustion device 100 according to the present embodiment, the control device 8 controls the operation of the adjustment mechanism 7 in such a manner that the injection flow rate of ammonia from the ammonia injection nozzle 41 is higher than the injection flow rate of pulverized coal from the pulverized coal injection nozzle 43. Depending on the magnitude relationship between the injection flow rate of ammonia and the injection flow rate of pulverized coal, the shape of the flame F formed in front of the burner 4 and the phenomenon occurring in the flame F vary. Hereinafter, the shape of the flame F and a phenomenon occurring in the flame F will be described with reference to Figs. 6 and 7.

[0047]

Fig. 6 is a diagram for explaining the flame F formed by

the combustion device 100 according to the present embodiment. That is, the flame F illustrated in Fig. 6 is a flame of the case where the injection flow rate of ammonia is faster than the injection flow rate of pulverized coal.

5 [0048]

In the example of Fig. 6, the flame F has an elongated shape extending along the central axis of the burner 4. In the vicinity of a surface layer of the flame F, as indicated by broken line arrows A5, a flow of air injected from the air supply unit 5 is formed. The pulverized coal injected from the pulverized coal injection nozzle 43 is pulled by the flow of air injected from the air supply unit 5 and flows in the vicinity of the surface layer of the flame F. Therefore, the pulverized coal injected from the pulverized coal injection nozzle 43 flows in the vicinity of the surface layer of the flame F along the flow of air indicated by the broken line arrows A5 as indicated by broken-line arrows A6. As a result, the pulverized coal burns and NO_x is generated in a region R1 in the vicinity of the surface layer of the flame F. The region R1 is a combustion region of the pulverized coal.

[0049]

In the example of Fig. 6, the injection flow rate of ammonia is faster than the injection flow rate of pulverized coal. Therefore, since the ammonia injected from the ammonia injection nozzle 41 is less likely to be pulled by the flow of the air injected from the air supply unit 5, the ammonia

flows through the center of the flame F in the axial direction of the burner 4 as indicated by solid arrows A7. The direction of a flow of ammonia can actually be various directions; however, the main direction is the axial direction of the burner 4. As a result, ammonia (NH_3) is decomposed into NH_2 , NH , and N in a region R2, where there is less oxygen, on the center side of the flame F. The region R2 is located radially inward with respect to the region R1. The region R2 is a decomposition region of ammonia. The region R2 has an elongated shape extending along the central axis of the burner 4.

[0050]

Then, NO_x is reduced by NH_2 , NH , and N in a region R3 on the distal end side of the flame F. The region R3 is positioned on the front side with respect to the region R2. The region R3 is a reduction region of NO_x .

[0051]

Fig. 7 is a diagram for explaining a flame F formed by a combustion device according to a comparative example. In the comparative example, unlike the present embodiment, the injection flow rate of ammonia is lower than the injection flow rate of pulverized coal. That is, the flame F illustrated in Fig. 7 is a flame of a case where the injection flow rate of ammonia is lower than the injection flow rate of pulverized coal.

[0052]

In the example of Fig. 7, the flame F has a shape

expanded in the radial direction as compared with the example of Fig. 6. Similarly to the example of Fig. 6, as indicated by broken line arrows A5 and A6, air injected from an air supply unit 5 and pulverized coal injected from a pulverized coal injection nozzle 43 flow in the vicinity of a surface layer of the flame F. In the region R1 in the vicinity of the surface layer of the flame F, the pulverized coal burns, and NO_x is generated.

[0053]

10 In the example of Fig. 7, the injection flow rate of ammonia is lower than the injection flow rate of pulverized coal. Therefore, the ammonia injected from an ammonia injection nozzle 41 is easily pulled by a flow of the air injected from the air supply unit 5. Therefore, most of the ammonia injected from the ammonia injection nozzle 41 flows along the flow of the air indicated by the broken line arrows A5 as indicated by solid line arrows A7. As a result, ammonia burns, and NO_x is generated in a region R4, where there is a large amount of oxygen, away from the center of the flame F towards the surface layer side. The region R4 is a combustion region of ammonia.

[0054]

25 A part of the ammonia injected from the ammonia injection nozzle 41 is decomposed into NH₂, NH, and N on the center side of the flame F where there is less oxygen. Then, NO_x is reduced by NH₂, NH, and N in a region R3 on the distal end side of the flame F.

[0055]

In the comparative example illustrated in Fig. 7, unlike the example of Fig. 6, most of the ammonia injected from the ammonia injection nozzle 41 burns to generate NOx.

5 Therefore, in addition to NOx generated by combustion of pulverized coal, NOx is also generated by combustion of ammonia. Therefore, the amount of NOx generated increases. In addition, most of the ammonia injected from the ammonia injection nozzle 41 burns and thus is not decomposed.

10 Therefore, the amount of NH_2 , NH , and N generated by decomposition of ammonia is reduced. Therefore, reduction of NOx is not sufficiently performed, and the amount of NOx emission increases.

[0056]

15 As described above, in the present embodiment, the control device 8 controls the operation of the adjustment mechanism 7 in such a manner that the injection flow rate of ammonia from the ammonia injection nozzle 41 is higher than the injection flow rate of pulverized coal from the

20 pulverized coal injection nozzle 43. As a result, as in the example of Fig. 6, the ammonia injected from the ammonia injection nozzle 41 can be sent to the region R2 where there is less oxygen on the center side of the flame F to be decomposed. Therefore, the generation of NOx due to

25 combustion of ammonia is suppressed, and the decomposition of ammonia is promoted. Therefore, NOx is effectively reduced, and NOx emission is suppressed.

[0057]

If the injection flow rate of ammonia from the ammonia injection nozzle 41 is excessively higher than the injection flow rate of pulverized coal from the pulverized coal injection nozzle 43, the shape of the flame F formed in front of the burner 4 and the phenomenon occurring in the flame F may deviate from the example of Fig. 6. For example, it is conceivable that the ammonia injected from the ammonia injection nozzle 41 extends ahead of the region R2, which is the decomposition region of ammonia, in a state where the ammonia is not sufficiently decomposed. In this case, the amounts of NH_2 , NH , and N generated by decomposition of ammonia are reduced, and the effect of suppressing NO_x emission can decrease. Therefore, the control device 8 preferably controls the operation of the adjustment mechanism 7 in such a manner that the injection flow rate of ammonia from the ammonia injection nozzle 41 is higher than the injection flow rate of pulverized coal from the pulverized coal injection nozzle 43 and is less than or equal to an upper limit rate. The upper limit rate is, for example, a rate higher by a predetermined ratio with respect to the injection flow rate of pulverized coal.

[0058]

Furthermore, in the present embodiment, as in the example of Fig. 6, the flame F formed by the combustion device 100 has an elongated shape. This increases the time during which the pulverized coal comes into contact with the oxygen,

thereby promoting the combustion of the pulverized coal. Therefore, generation and discharge of unburned fuel are suppressed.

[0059]

5 Fig. 8 is a schematic diagram illustrating a combustion device 100A according to a modification. As illustrated in Fig. 8, the combustion device 100A is an example in which the adjustment mechanism 7 of the combustion device 100 described above is replaced with an adjustment mechanism 7A.

10 [0060]

An ammonia injection nozzle 41A of the combustion device 100A has a different internal structure as compared with the ammonia injection nozzle 41 of the combustion device 100 described above. Fig. 9 is a cross-sectional view illustrating the inside of the ammonia injection nozzle 41A according to the modification. Specifically, Fig. 9 is a cross-sectional view taken along line X-X in Fig. 8 orthogonal to the central axis of the ammonia injection nozzle 41A.

20 [0061]

As illustrated in Fig. 9, a plurality of supply pipes 41e is included in a main body 41a of the ammonia injection nozzle 41A. In the example of Fig. 9, the number of supply pipes 41e is six. However, the number of supply pipes 41e may be other than six. A supply pipe 41e has a tubular shape such as a cylindrical shape. The supply pipes 41e extend in the axial direction of the main body 41a. In the example of

Fig. 9, the supply pipes 41e are arranged at equal intervals in the circumferential direction of the main body 41a.

However, the arrangement of the supply pipes 41e in the main body 41a is not limited to the example of Fig. 9. Ammonia

5 supplied from an ammonia tank 6 into the main body 41a passes through ammonia flow paths 41f each of which is an internal space of a supply pipe 41e and is injected from an injection port 41c. As described above, the ammonia injection nozzle 41 includes the plurality of ammonia flow paths 41f.

10 [0062]

The adjustment mechanism 7A in Fig. 8 adjusts the number of ammonia flow paths 41f through which ammonia flows among the plurality of ammonia flow paths 41f, thereby adjusting the injection flow rate of ammonia from the ammonia injection

15 nozzle 41A.

[0063]

Specifically, the adjustment mechanism 7A includes a switching valve 71A. The switching valve 71A is included in a flow path connecting the ammonia tank 6 and the ammonia

20 injection nozzle 41A. The switching valve 71A switches each of the supply pipes 41e between a state in which ammonia is supplied from the ammonia tank 6 and a state in which ammonia is not supplied from the ammonia tank 6. That is, the switching valve 71A switches supply pipes 41e serving as the

25 supply destination of ammonia among the plurality of supply pipes 41e. As a result, the number of ammonia flow paths 41f through which ammonia flows among the plurality of ammonia

flow paths 41f is adjusted.

[0064]

Among the plurality of ammonia flow paths 41f, the smaller the number of ammonia flow paths 41f through which ammonia flows, the smaller the total value of the flow path cross-sectional areas in the ammonia injection nozzle 41, which increases the flow rate of ammonia injected from the injection port 41c. For example, in a case where ammonia flows through only some ammonia flow paths 41f among the plurality of ammonia flow paths 41f, the flow rate of ammonia injected from the injection port 41c is faster as compared to a case where ammonia flows through all the ammonia flow paths 41f. Therefore, the adjustment mechanism 7A can adjust the injection flow rate of ammonia from the ammonia injection nozzle 41A by adjusting the number of ammonia flow paths 41f through which ammonia flows among the plurality of ammonia flow paths 41f. As described above, the adjustment mechanism 7A appropriately achieves adjustment of the injection flow rate of ammonia.

20 [0065]

Also in the combustion device 100A, similarly to the combustion device 100 described above, the control device 8 controls the adjustment mechanism 7A in such a manner that the injection flow rate of ammonia is higher than the injection flow rate of pulverized coal. For example, the control device 8 controls the switching valve 71A of the adjustment mechanism 7A in such a manner that the number of

ammonia flow paths 41f through which ammonia flows varies depending on the injection flow rate of pulverized coal. This makes it possible to make the injection flow rate of ammonia to be higher than the injection flow rate of
5 pulverized coal. Therefore, similarly to the combustion device 100 described above, the NOx emission is suppressed. In addition, generation and discharge of unburned fuel are suppressed.

[0066]

10 The control device 8 may change the number of ammonia flow paths 41f through which ammonia flows depending on a parameter other than the injection flow rate of pulverized coal. For example, the control device 8 may change the number of ammonia flow paths 41f through which ammonia flows
15 depending on the required combustion amount in the furnace 2, the required load of the boiler 1, or the required power generation amount of the boiler 1.

[0067]

Although the embodiments of the present disclosure have
20 been described with reference to the accompanying drawings, it is naturally understood that the present disclosure is not limited to the above embodiments. It is clear that those skilled in the art can conceive various modifications or variations within the scope described in the claims, and it
25 is understood that they are naturally also within the technical scope of the present disclosure.

[0068]

In the above description, the adjustment mechanism 7 and the adjustment mechanism 7A have been described as examples of the adjustment mechanism that adjusts the injection flow rate of ammonia from the ammonia injection nozzle 41.

5 However, a mechanism other than the adjustment mechanism 7 or the adjustment mechanism 7A may be used as long as the mechanism has a function of adjusting the injection flow rate of ammonia from the ammonia injection nozzle 41.

Furthermore, the adjustment mechanism 7 that adjusts the
10 opening area of the injection port 41c of the ammonia injection nozzle 41 and the adjustment mechanism 7A that adjusts the number of ammonia flow paths 41f through which ammonia flows among the plurality of ammonia flow paths 41f may be used in combination.

15 [0069]

The examples in which the combustion devices 100 and 100A are provided to the furnace 2 of the boiler 1 have been described above. However, the furnace in which the combustion device 100 or 100A is used only required to be a
20 furnace that burns fuel to generate combustion heat. The combustion devices 100 and 100A can be used in various furnaces of equipment other than the boiler 1.

[0070]

The present disclosure contributes to stabilization of
25 combustion by a combustion device used in a boiler or the like and a reduction in the frequency repairs of the combustion device and thus can contribute to, for example,

goal 7 of the sustainable development goals (SDGs) "Ensure access to affordable, reliable, sustainable and modern energy for all" and goal 13 "Take urgent action to combat climate change and its impacts".

5

Reference Signs List

[0071]

1: Boiler, 2: Furnace, 7: Adjustment Mechanism, 7A: Adjustment Mechanism, 8: Control Device, 41: Ammonia Injection Nozzle, 41A: Ammonia Injection Nozzle, 41c: Injection Port, 41f: Ammonia Flow Path, 43: Pulverized Coal Injection Nozzle, 43b: Injection Port, 100: Combustion Device, 100A: Combustion Device

CLAIMS:

1. A combustion device comprising:
 - an ammonia injection nozzle having an injection port facing an internal space of a furnace;
 - an air injection nozzle having an injection port facing the internal space of the furnace and disposed in such a manner as to surround the ammonia injection nozzle;
 - a pulverized coal injection nozzle having an injection port facing the internal space of the furnace and disposed in such a manner as to surround the air injection nozzle;
 - an adjustment mechanism that adjusts an injection flow speed of ammonia from the ammonia injection nozzle; and
 - a control device that controls an operation of the adjustment mechanism in such a manner that the injection flow speed of ammonia from the ammonia injection nozzle is higher than an injection flow speed of pulverized coal from the pulverized coal injection nozzle;wherein the control device that controls the operation of the adjustment mechanism in such a manner that the injection flow speed of ammonia from the ammonia injection nozzle is equal to a rate at which in a flame formed by a burner having the ammonia injection nozzle and the pulverized coal injection nozzle, a decomposition region of ammonia located on a center side of the flame and a reduction region of NO_x is positioned on a distal end side of the flame with respect to the decomposition region are formed.
2. The combustion device according to claim 1,
 - Wherein the control device that controls the operation of the adjustment mechanism in such a manner that the injection flow speed of ammonia from the ammonia injection nozzle changes according to a change of the injection flow speed of pulverized coal from the pulverized coal injection nozzle and is higher than the injection flow speed of pulverized coal from the pulverized coal injection nozzle.
3. The combustion device according to claim 1 or 2,
 - wherein the adjustment mechanism includes a mechanism that adjusts an opening area of the injection port of the ammonia injection nozzle.
4. The combustion device according to any one of claims 1 to 3,

wherein the ammonia injection nozzle comprises a plurality of ammonia flow paths, and

the adjustment mechanism includes a mechanism that adjusts a number of ammonia flow paths through which ammonia flows among the plurality of ammonia flow paths.

5. A boiler comprising the combustion device according to any one of claims 1 to 4.

IHI Corporation
Patent Attorneys for the Applicant/Nominated Person
SPRUSON & FERGUSON

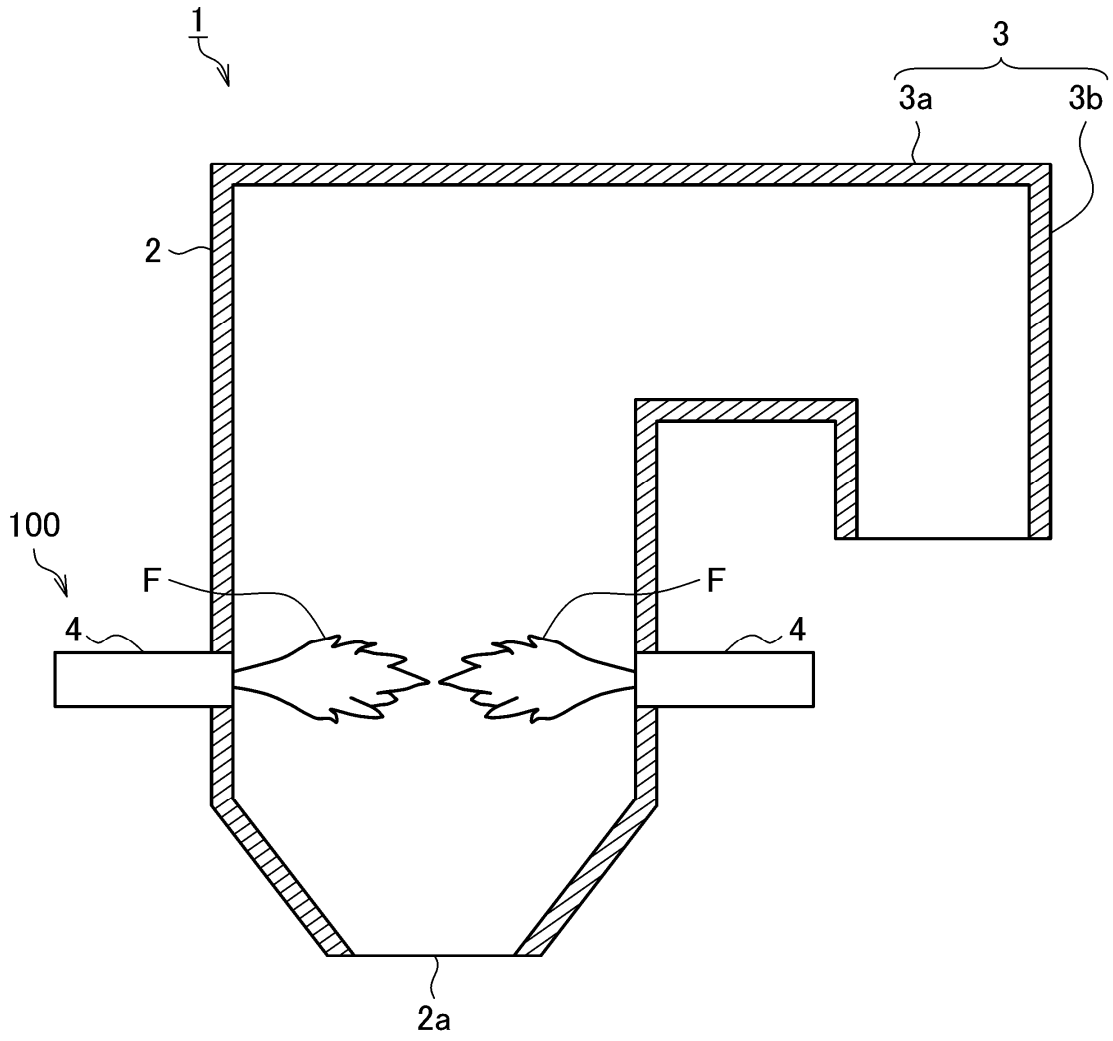


FIG. 1

100

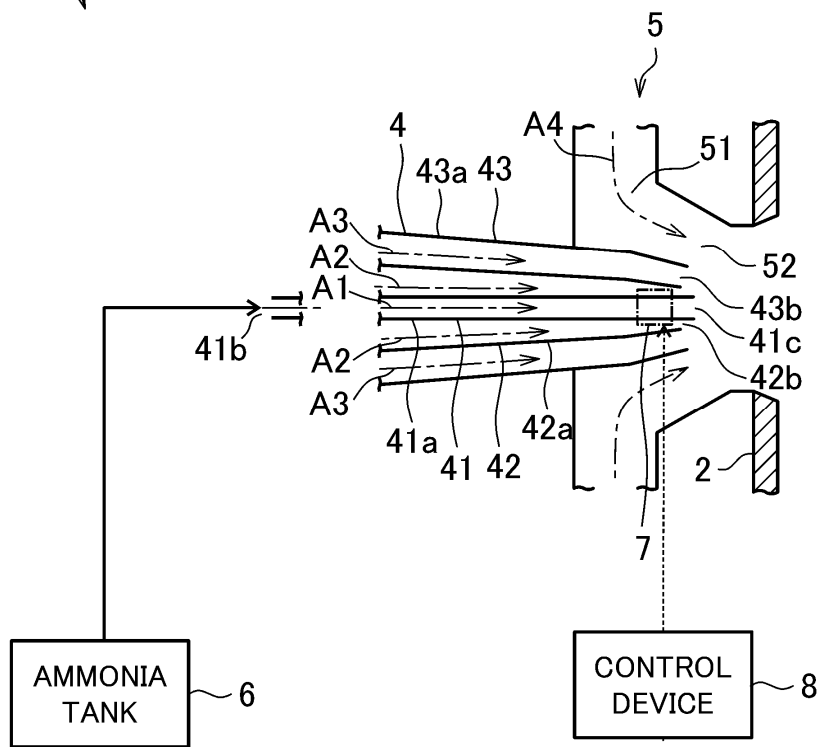


FIG. 2

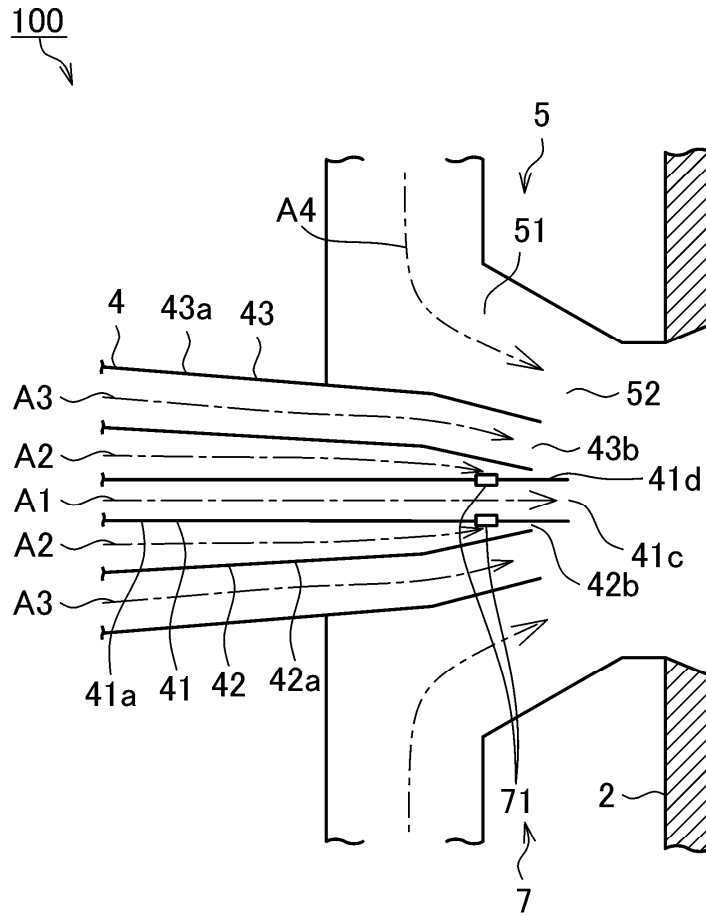


FIG. 3

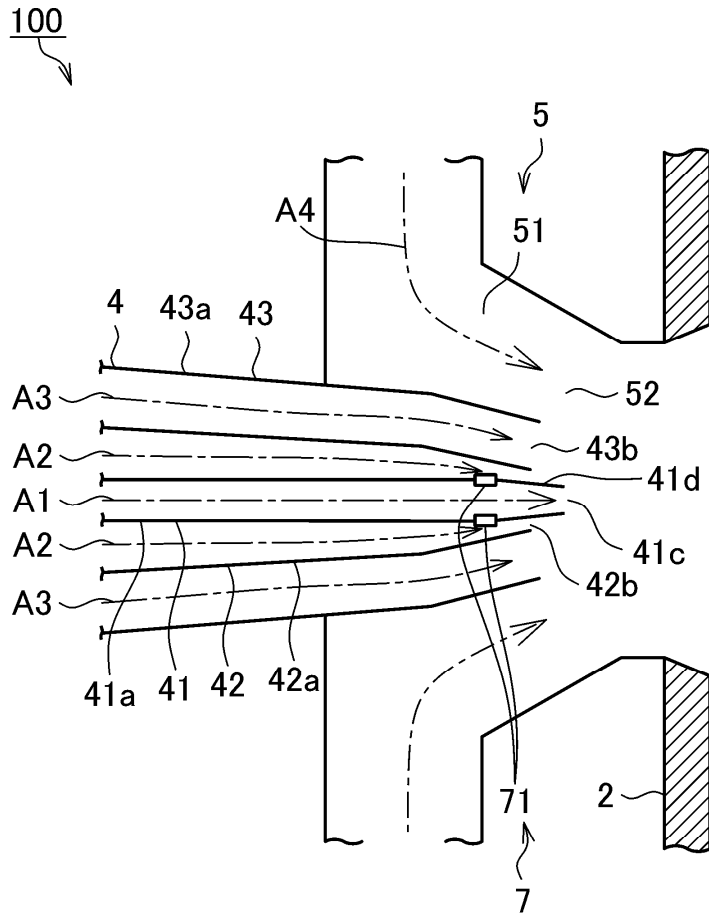


FIG. 4

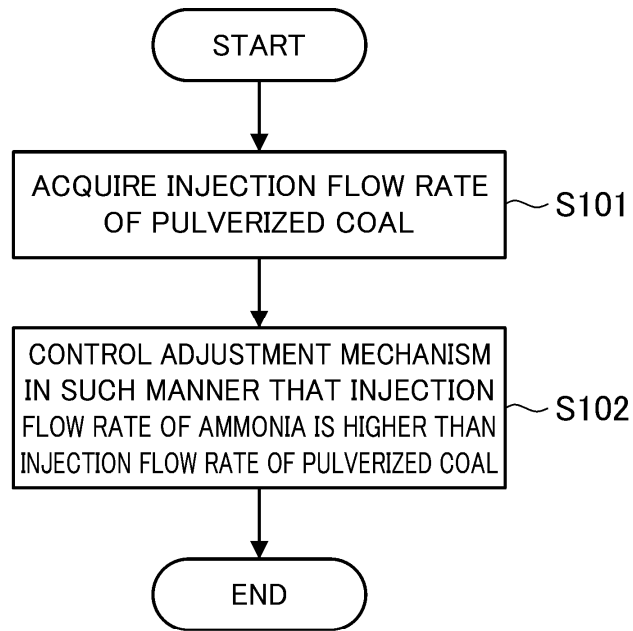


FIG. 5

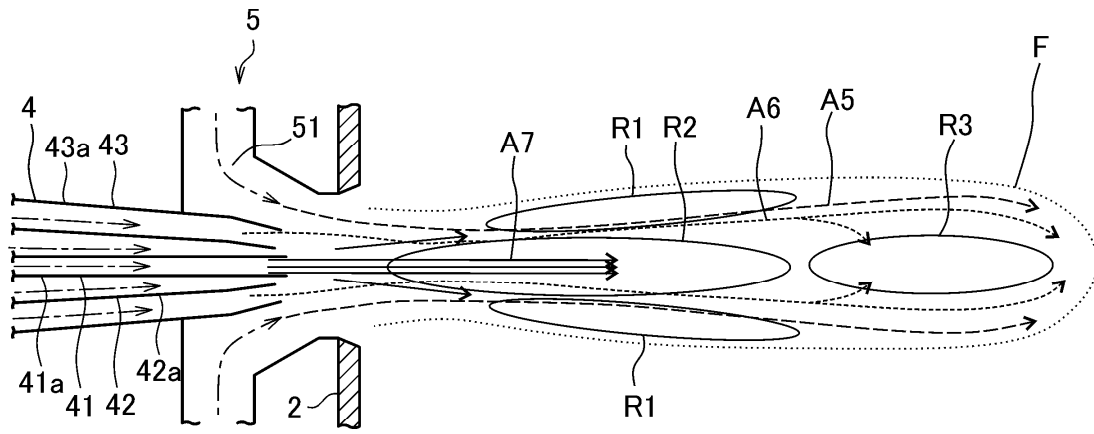


FIG. 6

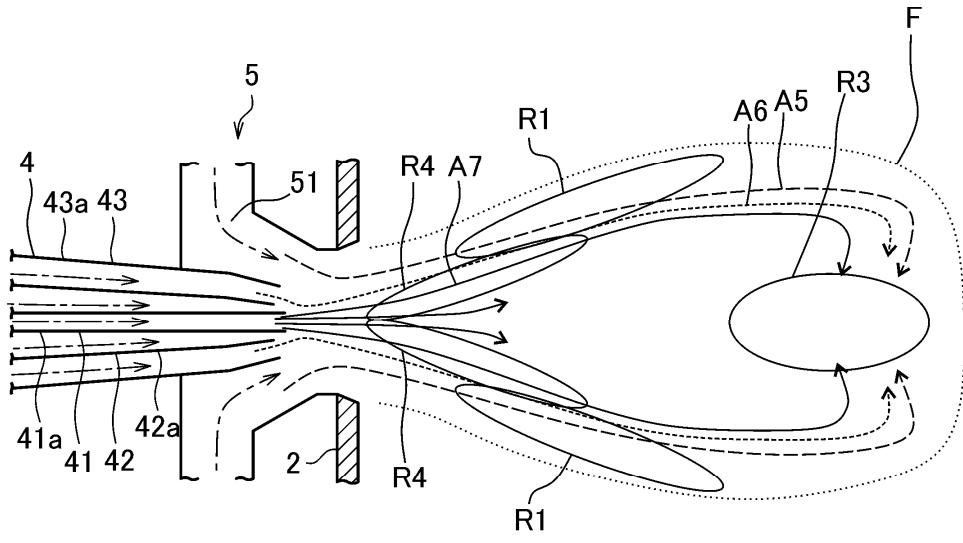


FIG. 7

100A

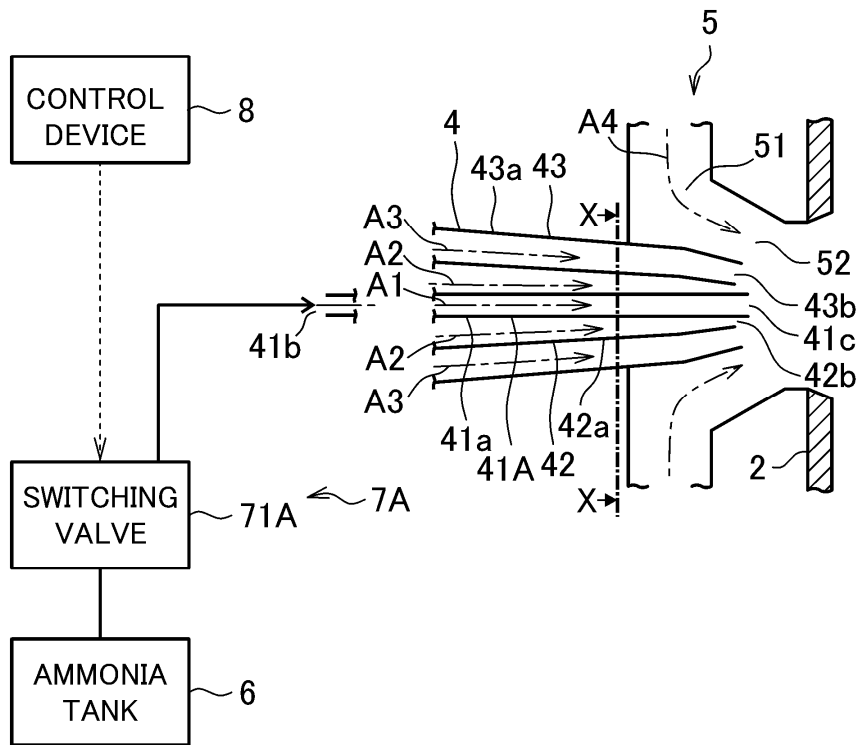


FIG. 8

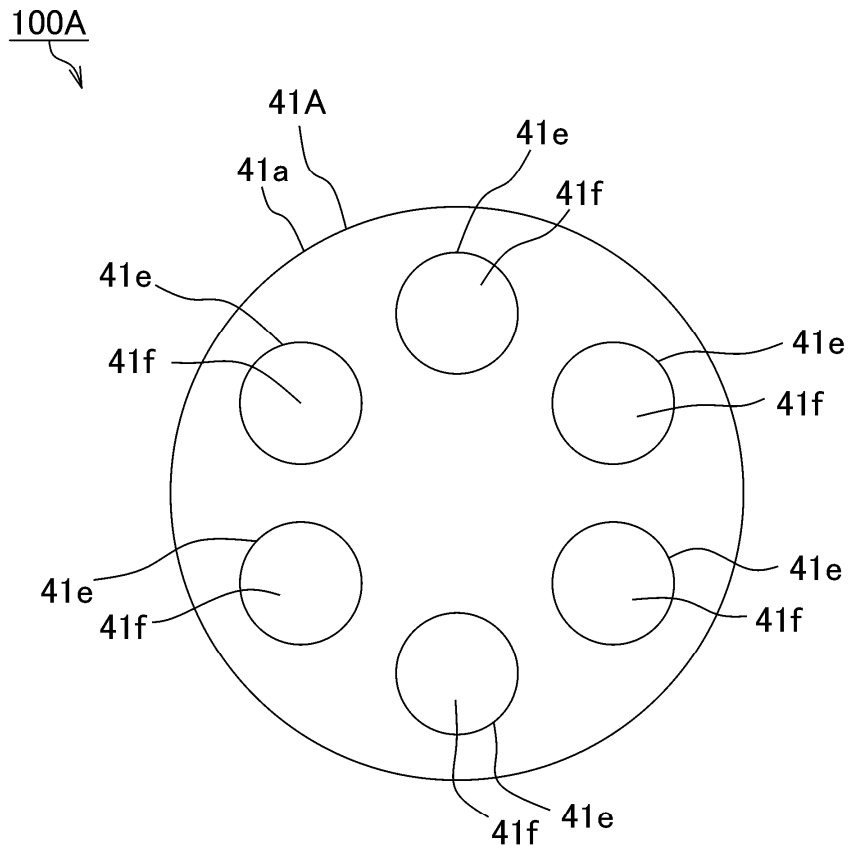


FIG. 9