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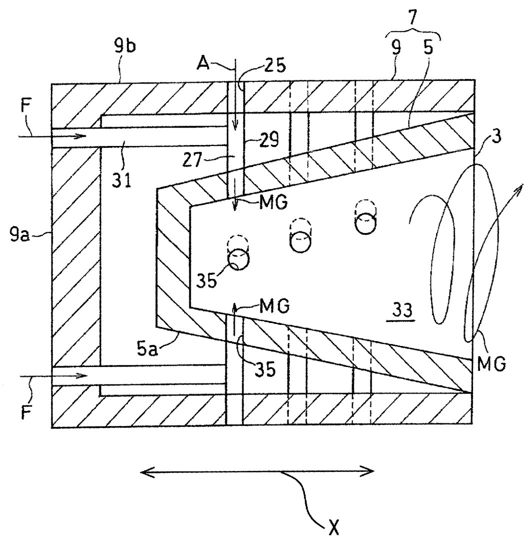
(54) BURNER DEVICE AND MULTI-TUBE THROUGH-FLOW BOILER DEVICE

(57) A burner device (1) for supplying a mixture (MG) of a fuel gas (F) and a combustion-supporting gas (A) into a combustion region (R) includes: a primary mixing path (27) configured to be introduced with and mix the fuel gas and the combustion-supporting gas; a secondary mixing chamber (33) defined inside a wall surface having a rotating-body shape and configured to be introduced with and further mix the mixture (MG) from the primary mixing path (27); and a plurality of mixture introduction holes (35) defined in a circumferential wall (5a) of the secondary mixing chamber (33) and configured to introduce the mixture (MG) from the primary mixing path (27) into the secondary mixing chamber (33) in an eccentric direction of the secondary mixing chamber (33) to generate a swirling flow of the mixture (MG).

Fig. 2



EP 3 719 396 A1

Description

CROSS REFERENCE TO THE RELATED APPLICATION

[0001] This application is based on and claims Convention priority to Japanese patent application No. 2017-229025, filed November 29, 2017, the entire disclosure of which is herein incorporated by reference as a part of this application.

BACKGROUND OF THE INVENTION

(Field of the Invention)

[0002] The present invention relates to a burner device for mixing and burning, for example, a fuel gas such as hydrogen gas and another type of gas.

(Description of Related Art)

[0003] In recent years, in order to achieve a so-called low-carbon society, a burner device that uses hydrogen as a fuel has been proposed to reduce emissions of carbon dioxide that causes environmental issues such as global warming (see, for example, Patent Document 1).

[Related Document]

[Patent Document]

[0004] [Patent Document 1] U.S. Patent Application Publication No. 2012/0258409

SUMMARY OF THE INVENTION

[0005] Combustion of a highly reactive fuel such as a hydrogen-containing fuel, however, occurs at high temperature and thus is likely to cause generation of NOx, which needs to be suppressed.

[0006] An object of the present invention is to provide a burner device capable of suppressing generation of NOx even where a highly reactive fuel such as hydrogen gas is used.

[0007] In order to achieve the object, the present invention provides a burner device for supplying a mixture of a fuel gas and a combustion-supporting gas into a combustion region, the burner device including a mixture injection body including:

a primary mixing path configured to be introduced with the fuel gas and the combustion-supporting gas and mix the fuel gas and the combustion-supporting gas;

a secondary mixing chamber located on an inner diameter side of the primary mixing path and defined inside a wall surface having a rotating-body shape, the secondary mixing chamber being configured to be introduced with and further mix the mixture from the primary mixing path, and the secondary mixing chamber having an injection opening configured to inject the mixture into the combustion region; and

a plurality of mixture introduction holes defined in a circumferential wall of the secondary mixing chamber and configured to introduce the mixture from the primary mixing path into the secondary mixing chamber in an eccentric direction of the secondary mixing chamber to generate a swirling flow of the mixture.

[0008] According to this configuration, two types of gas can be mixed in two steps so as to promote premixing and produce a homogeneous mixture. This makes it possible to suppress local increase in flame temperature so as to reduce generation of NOx. Moreover, it is possible to further promote mixing by generating a swirling flow in the secondary mixing chamber inside the mixture injection body.

[0009] In a burner device according to one embodiment of the present invention, the mixture injection body may further include: a first gas path configured to introduce one of the fuel gas and the combustion-supporting gas into the primary mixing path from radially outside; and a second gas path configured to introduce the other of the fuel gas and the combustion-supporting gas into the primary mixing path in a direction intersecting the first gas path. According to this configuration, a shearing force generated when the fuel gas and the combustion-supporting gas intersect can promote a first step of mixing in the primary mixing path.

[0010] A burner device according to one embodiment of the present invention may include a plurality of the mixture injection bodies. According to this configuration, a necessary amount of the fuel as a whole can be injected in a distributed manner from the plurality of mixture injection bodies (injection openings) so as to more effectively suppress local temperature increase. Thus, generation of NOx can further be suppressed.

[0011] In a burner device according to one embodiment of the present invention, the secondary mixing chamber may have an increasing diameter toward a downstream side. According to this configuration, by generating a swirling flow in the secondary mixing chamber and feeding the mixture along the wall surface of the secondary mixing chamber, it is possible to prevent backfire because this prevents the mixture from flowing at low velocity in the vicinity of the wall surface.

[0012] In a burner device according to one embodiment of the present invention, where the secondary mixing chamber has an increasing diameter toward the downstream side, the mixture injection body may further include a supplementary cone member disposed concentrically to the secondary mixing chamber and configured to inject the combustion-supporting gas into the secondary mixing chamber from a most-upstream part of the secondary mixing chamber. This configuration makes it possible to inject the combustion-supporting gas from the supplementary cone member to prevent backfire from a central part of the secondary mixing chamber.

[0013] In a burner device according to one embodiment of the present invention, the secondary mixing chamber may have a decreasing diameter toward the downstream side. This configuration makes it possible to prevent uneven distribution of the fuel in the swirling flow of the mixture toward outside to achieve more homogeneous mixing. Also, since the injection opening has a smaller opening area, the flow velocity of the mixture is increased such that the backfire phenomenon can be effectively prevented.

[0014] A multi-tube once-through boiler device according to the present invention may include:

a water pipe group including a plurality of water pipes arranged in an annular manner;
a connecting wall connecting the adjacent water pipes; and
the burner device including a plurality of the mixture injection bodies, the burner device being arranged so as to inject the mixture into a combustion chamber defined by the water pipe group and the connecting wall, wherein
the plurality of mixture injection bodies of the burner device are arranged concentrically to the water pipe group in an annular manner.

[0015] According to this configuration, the water pipe group is arranged outside the mixture injection bodies for generating swirling flows of the mixture so that flame generated in the combustion region is brought into collision with the water pipes. Therefore, heat transfer to the water pipes can further be promoted, enhancing efficiency of the boiler device.

[0016] In a multi-tube once-through boiler device according to one embodiment of the present invention, the plurality of mixture injection bodies arranged in an annular manner may be disposed so as to generate swirling flows of the mixture in the same direction. This configuration makes it possible to generate swirling flows with large flame inside the combustion chamber to effectively bring the flame into collision with the water pipes. Therefore, heat transfer to the water pipes can further be promoted.

[0017] In a multi-tube once-through boiler device according to one embodiment of the present invention, the plurality of mixture injection bodies arranged in an annular manner may be disposed such that the adjacent mixture injection bodies generate swirling flows of the mixture in opposite directions. This configuration makes it possible to generate flows of flame toward radially outside between the adjacent mixture injection bodies to effectively bring the flame into collision with the water pipes. Therefore, heat transfer to the water pipes can further be promoted.

[0018] The present invention encompasses any combination of at least two features disclosed in the claims and/or the specification and/or the drawings. In particular, any combination of two or more of the appended claims should be equally construed as included within the scope of the present invention.

BRIEF DESCRIPTION OF THE DRAWINGS

[0019] The present invention will be more clearly understood from the following description of embodiments thereof, when taken in conjunction with the accompanying drawings. However, the embodiments and the drawings are given only for the purpose of illustration and explanation, and are not to be taken as limiting the scope of the present invention in any way whatsoever, which scope is to be determined by the appended claims. In the accompanying drawings, like reference numerals are used to denote like parts throughout the several views. In the figures,

Fig. 1 is a longitudinal section view showing a schematic structure of a burner device according to one embodiment of the present invention;
Fig. 2 is a longitudinal section view showing a peripheral structure of a mixture injection body of the burner device shown in Fig. 1;
Fig. 3 is a cross-section view showing the peripheral structure of the mixture injection body shown in Fig. 2;
Fig. 4 is a longitudinal section view showing, in an enlarged manner, a part of the peripheral structure of the mixture injection body shown in Fig. 2;
Fig. 5 is a longitudinal section view showing a peripheral structure of a mixture injection body according to a variant of the burner device shown in Fig. 1;
Fig. 6 is a longitudinal section view showing a peripheral structure of a mixture injection body according to another variant of the burner device shown in Fig. 1;
Fig. 7 is a longitudinal section view showing a schematic structure of a boiler device according to a first embodiment of the present invention;
Fig. 8 is a cross-section view showing a schematic structure of the boiler device shown in Fig. 7; and
Fig. 9 is a cross-section view showing a schematic structure of a boiler device according to a second embodiment of the present invention.

DESCRIPTION OF THE EMBODIMENTS

[0020] Hereinafter, embodiments of the present invention will be described with reference to the drawings. Fig. 1 shows a burner device according to one embodiment of the present invention. The burner device 1 shown in Fig. 1 is configured to supply a mixture MG of a fuel gas and a combustion-supporting gas into a combustion region R. The burner device 1 is, for example, used as a heating device for a power apparatus such as a boiler and a gas turbine.

[0021] The fuel gas may be, for example, a fuel that has a high combustion velocity and a wide range of combustible concentrations. In the present embodiment, a hydrogen-containing gas such as a hydrogen gas is used as the fuel gas. In the present embodiment, an air A is used as the combustion-supporting gas. Other than air, for example, a gas in which the oxygen concentration in the air is adjusted or an exhaust gas may be used as the combustion-supporting gas. In the following description, the fuel gas is represented as "fuel F" and the combustion-supporting gas is represented as "air A".

[0022] The burner device 1 includes a mixture injection body 7 including a cone member 5 that defines an injection opening 3 for injecting the mixture MG into the combustion region R. The mixture injection body 7 includes: the cone member 5 having a hollow truncated-cone shape; and a hollow tubular member 9 for housing the cone member 5. In the illustrated example, the hollow tubular member 9 has a hollow cylindrical shape. The cone member 5 and the hollow tubular member 9 are arranged concentrically to each other. The hollow tubular member 9 may also have a polygonal cylindrical shape. In this embodiment, the burner device 1 includes a plurality (12 arranged in a matrix of 4×3 in this example) of the mixture injection bodies 7, i.e., a plurality of the cone members 5. In the following description, a direction that is in parallel to an axial direction of each cone member 5 is simply referred to as "axial direction X." A radial direction of the cone member 5 is simply referred to as "radial direction".

[0023] The burner device 1 may include a non-illustrated pilot burner for ignition, besides the mixture injection body 7. In ignition, a fuel for ignition is injected from the pilot burner into the combustion region R.

[0024] The burner device 1 includes: an air introduction header 11 for introducing air A into the mixture injection body 7; and a fuel introduction header 13 for introducing a fuel F into the mixture injection body 7 on an upstream side of the mixture injection body 7. The fuel introduction header 13 includes a downstream-side wall 13a to which an upstream-side bottom wall 9a of the hollow tubular member 9 is fitted. The fuel introduction header 13 includes an upstream-side wall 13b to which a fuel introduction pipe 15 defining an introduction path for the fuel F is connected. That is, the fuel introduction pipe 15 is provided so as to extend in an axial direction X and introduces the fuel F into the fuel introduction header 13 in the axial direction X. The air introduction header 11 is formed so as to enclose the mixture injection body 7, the fuel introduction header 13 and the fuel introduction pipe 15 arranged as described above. The air introduction header 11 has a side wall 11a to which an air introduction pipe 17 defining an introduction path for the air A is connected.

[0025] The fuel F introduced into the fuel introduction header 13 is distributed in a direction of a plane in parallel with the axial direction X that is also an introduction direction of the fuel F, and then is introduced into the hollow tubular member 9. The structure of the hollow tubular member 9 will be described later in detail. In the illustrated example, a rectifying plate 19 is provided to the downstream-side wall 13a of the fuel introduction header 13, at a location downstream of the fuel introduction pipe 15, so as to protrude toward the upstream side. The fuel F introduced into the fuel introduction header 13 collides against the rectifying plate 19 so as to be substantially uniformly distributed in the direction of the plane in parallel with the axial direction X. It is also possible to omit the rectifying plate 19 such that the fuel F directly collides against the downstream-side wall 13a of the fuel introduction header 13. The air A introduced into the air introduction header 11 passes through a gap 21 between the air introduction header 11 and the fuel introduction header 13 and then is introduced into the hollow tubular member 9.

[0026] As shown in Fig. 2, the hollow tubular member 9 of the mixture injection body 7 has a side wall 9b having an air path (first gas path) 25 that penetrates the side wall 9b and extend further inside. The air A from the air introduction header 11 passes through the air path 25 and then is introduced into a mixing path (hereinafter, referred to as "primary mixing path 27") defined outside each cone member 5. That is, the air path 25 introduces the air A into the primary mixing path 27 from radially outside. In the illustrated example, there are a plurality of the air paths 25. In the illustrated example, each primary mixing path 27 is formed as a path extending further inside from each air path 25 to a circumferential wall 5a of the cone member 5. In the following description, the entire path extending from the side wall 9b of the hollow tubular member 9 of the present embodiment to the circumferential wall 5a of the cone member 5 to define the air path 25 and the primary mixing path 27 is referred to as "gas path 29" as needed.

[0027] On the other hand, the upstream-side bottom wall 9a of the hollow tubular member 9 has a fuel path (second gas path) 31 for introducing the fuel F from the fuel introduction header 13 into the primary mixing path 27. In this example, as shown in Fig. 3, there are a plurality of the fuel paths 31 arranged along a circumferential edge of the upstream-side bottom wall 9a of the hollow tubular member 9 at equal intervals. As shown in Fig. 4, each fuel path 31 extends in the axial direction X. Each fuel path 31 penetrates the upstream-side bottom wall 9a of the hollow tubular member 9 to further extend to the downstream side and is connected to an upstream end of the primary mixing path 27. In other words, the air path 25 refers to a portion of the gas path 29 which is on the upstream side of a connecting part to the fuel path 31, and the primary mixing path 27 refers to a portion of the gas path 29 which is on the downstream side of the connecting part. In the primary mixing path 27, the fuel F introduced from the fuel introduction header 13 and the air A introduced from the air introduction header 11 are mixed with each other.

[0028] As shown in Fig. 2, the circumferential wall 5a of the cone member 5 has a plurality of mixture introduction holes 35 for introducing the mixture MG from the primary mixing paths 27 into a mixing chamber (hereinafter, referred to as "secondary mixing chamber 33") that is an inner space of the cone member 5. That is, the secondary mixing chamber 33 is defined inside a truncated-cone-shaped wall surface located on an inner diameter side of the primary mixing paths 27. In the secondary mixing chamber 33, the mixture MG introduced from the primary mixing paths 27 is further mixed. In this example, as shown in Fig. 3, the plurality of mixture introduction holes 35 are provided to the circumferential wall 5a of the cone member 5, at multiple (three in this example) different positions in the axial direction X at equal intervals in a circumferential direction. In Fig. 3, the mixture introduction holes 35 at different positions in the axial direction X are denoted, in the order of those at closer positions to those at further positions in the drawing, as mixture introduction holes 35A, 35B, 35C with solid lines, dot lines, and one-dot chain lines, respectively. The gas paths 29, which will be described later, are shown in the same way so as to be distinguished. The mixture introduction holes 35 at different positions in the axial direction X are provided so as to have circumferential positions displaced from each other.

[0029] Thus, the mixture introduction holes 35 provided at multiple (three in this example) different positions in the axial direction X make it possible to additionally inject the mixture MG into the mixture MG from the upstream side to thereby promote mixing. Also, thanks to the arrangement that the mixture introduction holes 35 at different positions in the axial direction X have circumferential positions displaced from each other, more uniform mixing can be achieved.

[0030] The plurality of mixture introduction holes 35 are provided at the respective positions in the axial direction X so as to extend in respective eccentric directions of the secondary mixing chamber 33. That is, each mixture introduction hole 35 extends in a direction inclined with respect to the radial direction. The plurality of mixture introduction holes 35 at the same position in the axial direction X have the same inclination angle with respect to the radial direction. Thanks to this configuration of the plurality of mixture introduction holes 35, the mixture introduction holes 35 introduce the mixture MG from the primary mixing paths 27 into the secondary mixing chamber 33 in the eccentric directions of the secondary mixing chamber 33 to generate a swirling flow of the mixture MG.

[0031] Specifically, in this embodiment, each gas path 29 including the air path 25 and the primary mixing path 27 is defined at a corresponding position and a corresponding angle to those of each mixture introduction hole 35 of the cone member 5. In other words, the numbers of the air paths 25 and the primary mixing paths 27 provided to the hollow tubular member 9 correspond to the number (12 in this example) of the mixture introduction holes 35, and each gas path 29 is provided so as to have the same axis (mixture introduction axis) C1 as that of the corresponding mixture introduction hole 35 of the cone member 5.

[0032] The above structure of the air paths 25, the primary mixing paths 27 and the mixture introduction holes 35 makes it possible to effectively generate a swirling flow of the mixture MG in the secondary mixing chamber 33 by a simple structure. However, as long as the plurality of mixture introduction holes 35 are provided such that the mixture introduction holes at least one position in the axial direction X extend in the eccentric direction of the secondary mixing chamber 33, it is possible to generate a swirling flow of the mixture MG in the secondary mixing chamber 33. Other features of the air paths 25, the primary mixing paths 27 and the mixture introduction holes 35 are not limited to those in the illustrated example.

[0033] In this embodiment, as shown in Fig. 4, each fuel path 31 is configured to introduce the fuel F into the primary mixing path 27 in a direction intersecting each air path 25. Specifically, the number of the fuel paths 31 provided to the hollow tubular member 9 corresponds to the number (12 in this example) of the air paths 25, and each fuel path 31 is arranged such that an axis (fuel introduction axis) C2 thereof is perpendicular to an axis (air introduction axis) C3 of the corresponding air path 25.

[0034] Thus, each fuel path 31 is configured to introduce the fuel F into the primary mixing path 27 in a direction intersecting the air path 25 so that a shearing force generated when the fuel F and the air A intersect can promote a first step of mixing in the primary mixing path 27. In order to promote mixing of the fuel F and the air A by the shearing force, an intersection angle α defined between the fuel introduction axis C2 and the air introduction axis C3 is preferably 90° as in this example but is not limited to 90°. Also, it is not essential that each fuel path 31 is configured to introduce the fuel F into the primary mixing path 27 in a direction intersecting the air path 25. For example, each fuel path 31 may also be formed so as to be connected to the air path 25 in a direction displaced with respect to the air introduction axis C3 so that a swirling flow of the fuel F is generated in the primary mixing path 27 to promote mixing of the fuel F and the air A in the primary mixing path 27.

[0035] The respective introduction paths for introducing the fuel F and the air A into the primary mixing path 27 may be switched. That is, the fuel F may pass through the first gas path which has been described as the air path 25, and the air A may pass through the second gas path which has been described as the fuel path 31. In such a case, the introduction headers 11, 13 and the introduction pipes 15, 17 are also exchanged in a corresponding manner for introduction of the air A and the fuel F.

[0036] The secondary mixing chamber 33 having a hollow truncated-cone shape as shown in Fig. 2 has an increasing diameter toward the downstream side. In such a case, as shown in Fig. 5 as a variant, a supplementary cone member 37 configured to inject the air A from a most-upstream part of the secondary mixing chamber 33 into the secondary mixing chamber 33 may be provided concentrically to the secondary mixing chamber 33. The supplementary cone member 37 is formed in a hollow truncated-cone shape having a decreasing diameter toward the downstream side. The air A to be injected from the supplementary cone member 37 may be, for example, supplied from the air introduction header 11 (Fig. 1) by a supplementary-air introduction path 39 provided for the supplementary cone member 37, which penetrates the fuel introduction header 13 (Fig. 1). By generating a swirling flow in the secondary mixing chamber 33 having an increasing diameter toward the downstream side and feeding the mixture MG along a wall surface of the secondary mixing chamber 33, it is possible to prevent backfire because this prevents the mixture MG from flowing at low velocity in the vicinity of the wall surface. Further, it is possible to inject the air A from the supplementary cone member 37 to prevent backfire from a central part of the secondary mixing chamber 33.

[0037] As shown in Fig. 6 as a variant, the secondary mixing chamber 33 may also have a decreasing diameter toward the downstream side. In such a case, it is possible to prevent uneven distribution of the fuel F in the swirling flow of the mixture MG toward outside to achieve more homogeneous mixing. Also, since the injection opening 3 has a smaller opening area, the flow velocity of the mixture is increased such that the backfire phenomenon can be effectively prevented.

[0038] It should be noted that the shape of the wall surface defining the secondary mixing chamber 33 may have a rotating-body shape other than the truncated-cone shape described as an example above. An example of such a rotating-body shape may include a cylindrical shape.

[0039] In this embodiment, as for the mixture injection body 7 for producing the mixture M and injecting it into the combustion region R, one example has been described in which tube members are combined, the tube members constituting the cone member 5, the hollow tubular member 9, as well as the respective elements for introducing and mixing the gas (such as the primary mixing path 27, the secondary mixing chamber 33, and the mixture introduction hole 35). The configuration of the mixture injection body 7, however, is not limited to this. That is, as long as the mixture injection body 7 is formed with the respective elements for introducing and mixing the gas as described in the present embodiment, the mixture injection body 7 may be, for example, a component formed by cutting a single metal block to shape the respective elements.

[0040] This embodiment has been described with reference to an example in which a plurality of mixture injection bodies 7 are provided. By providing a plurality of mixture injection bodies 7 as in this example, a necessary amount of the fuel F as a whole can be injected in a distributed manner from the plurality of mixture injection bodies 7 (injection openings 3) so as to more effectively suppress local temperature increase. Thus, generation of NOx can be suppressed. In such a case, the number and arrangement of the plurality of mixture injection bodies 7 are not limited to those of the above example and may be suitably selected depending on the design of an apparatus to which the burner device 1 is applied. It is also possible to provide only one mixture injection body 7 to the burner device 1.

[0041] According to the burner device 1 according to the present embodiment as described above, two types of gas can be mixed in two steps in the primary mixing path 27 and the secondary mixing chamber 33 so as to promote premixing and produce a homogeneous mixture MG. This makes it possible to suppress local increase in flame temperature so as to reduce generation of NOx. Moreover, it is possible to further promote mixing by generating a swirling flow in the secondary mixing chamber 33.

[0042] Next, a multi-tube once-through boiler device (hereinafter, simply referred to as "boiler device") 51 according to a first embodiment of the present invention, which is shown in Fig. 7, will be described. The boiler device 51 includes a burner device 1 according to one of the above embodiments. The boiler device 51 further includes a water pipe group 53 including a plurality of water pipes arranged in an annular manner (in two annular rows on inner and outer sides, in this example). The water pipes of the water pipe group 53 are communicated by an upper header 55 and a lower header 57 each having an annular shape. As shown in Fig. 8, the adjacent water pipes are connected by a connecting wall 59. The water pipe group 53 and the connecting wall 59 define a combustion chamber 61. The burner device 1 is arranged so as to inject the mixture MG into the combustion chamber 57. That is, the water pipe group 53 defining the combustion chamber 1 is arranged so as to surround the mixture injection bodies 7 for injecting the mixture MG in a plan view. In Fig. 8, the water pipe group in the outer row is omitted.

[0043] As shown in Fig. 8, in the burner device 1, the mixture injection bodies 7 are arranged concentrically to the water pipe group 53. Specifically, in the present embodiment, the plurality of mixture injection bodies 7 arranged in an annular manner are disposed so as to generate swirling flows of the mixture MG in the same direction. The boiler device 51 according to the present embodiment makes it possible to generate swirling flows F1 with large flame inside the combustion chamber 57 to effectively bring the flame into collision with the water pipe group 53, as shown in Fig. 8. Therefore, heat transfer to the water pipe group 53 can further be promoted.

[0044] In the illustrated example, besides the mixture injection bodies 7 arranged in an annular manner on an inner side of the water pipe group 53, there is another mixture injection body 7 arranged at a center part of the annular arrangement. By providing the mixture injection body 7 also at the center part, flame can be more uniformly distributed inside the combustion chamber 57, suppressing backfire. It is also possible to additionally arrange one or more rows of the mixture injection bodies 7 on an inner side the illustrated mixture injection bodies 7 arranged in an annular manner.

[0045] Fig. 9 shows a boiler device 51 according to a second embodiment. In this embodiment, the arrangement of the plurality of mixture injection bodies 7 in the burner device 1 is different from that of the first embodiment. That is, in this embodiment, the plurality of mixture injection bodies 7 arranged in an annular manner are disposed such that the adjacent mixture injection bodies 7 generate swirling flows of the mixture MG in opposite directions. Other features are the same as those of the boiler device 51 according to the first embodiment shown in Fig. 8.

[0046] The boiler device 51 according to the present embodiment makes it possible to generate flows F2 of flame toward radially outside between the adjacent mixture injection bodies 7, 7 to effectively bring the flame into collision with the water pipes 53, as shown in Fig. 8. Therefore, heat transfer to the water pipes 53 can further be promoted. Although the positional relationship between the water pipe group 53 and the mixture injection body 7 in a plan view is not limited to that of the illustrated example, it is preferable that each of the water pipes 53 is arranged on the outer side with respect to a circumferential position between the adjacent mixture injection bodies 7, 7 as shown in Fig. 8 in order to effectively bring the flame into collision with the water pipes 53 in the present embodiment.

[0047] Although, as for the boiler device 51 according to each of the above embodiments, examples have been described in which the plurality of mixture injection bodies 7 of the burner device 1, which are arranged in an annular manner, are disposed such that the mixture MG has a regular swirling direction(s), the arrangement of the mixture injection bodies 7 is not limited to those of the examples. That is, since the burner device 1 according to the present embodiment injects the mixture MG as swirling flows, instead of injecting the mixture MG in a direction in parallel with the water pipe group 53, as long as the mixture injection bodies 7 of the burner device 1 are arranged in an annular manner concentrically to the water pipe group 53, the effect that the flame produced by the mixture MG injected from the cone members 5 collides against the water pipes 53, promoting heat transfer to the water pipe group 53, can be provided.

[0048] It should be noted that the burner device 1 according to the present embodiment may be applied not only to the boiler device 51, but also to other types of power apparatuses such as a gas turbine, as described above.

[0049] Although the present invention has been fully described in connection with the embodiments thereof with reference to the accompanying drawings, various additions, modifications, or deletions may be made without departing from the scope of the invention. Accordingly, such additions, modifications, and deletions are to be construed as included within the scope of the present invention.

[Reference Numerals]

[0050]

1	Burner device
3	Injection opening
7	Mixture injection body
25	Air path (first gas path)
27	Primary mixing path
31	Fuel path (second gas path)
33	Secondary mixing chamber
35	Mixture introduction hole
51	Boiler device
53	Water pipe group
55	Connecting wall
57	Combustion chamber
A	Air (combustion-supporting gas)
F	Fuel (fuel gas)
MG	Mixture
R	Combustion region

Claims

1. A burner device for supplying a mixture of a fuel gas and a combustion-supporting gas into a combustion region, the burner device comprising a mixture injection body including:

a primary mixing path configured to be introduced with the fuel gas and the combustion-supporting gas and mix the fuel gas and the combustion-supporting gas;

a secondary mixing chamber located on an inner diameter side of the primary mixing path and defined inside a wall surface having a rotating-body shape, the secondary mixing chamber being configured to be introduced with and further mix the mixture from the primary mixing path, and the secondary mixing chamber having an

injection opening configured to inject the mixture into the combustion region; and
a plurality of mixture introduction holes defined in a circumferential wall of the secondary mixing chamber and configured to introduce the mixture from the primary mixing path into the secondary mixing chamber in respective eccentric directions of the secondary mixing chamber to generate a swirling flow of the mixture.

2. The burner device as claimed in claim 1, wherein the mixture injection body includes:

a first gas path configured to introduce one of the fuel gas and the combustion-supporting gas into the primary mixing path from radially outside; and
a second gas path configured to introduce the other of the fuel gas and the combustion-supporting gas into the primary mixing path in a direction intersecting the first gas path.

3. The burner device as claimed in claim 1 or 2, comprising a plurality of the mixture injection bodies.

4. The burner device as claimed in any one of claims 1 to 3, wherein the secondary mixing chamber has an increasing diameter toward a downstream side.

5. The burner device as claimed in claim 4, wherein the mixture injection body includes a supplementary cone member disposed concentrically to the secondary mixing chamber and configured to inject the combustion-supporting gas into the secondary mixing chamber from a most-upstream part of the secondary mixing chamber.

6. The burner device as claimed in any one of claims 1 to 3, wherein the secondary mixing chamber has a decreasing diameter toward a downstream side.

7. A multi-tube once-through boiler device comprising:

a water pipe group including a plurality of water pipes arranged in an annular manner;
a connecting wall connecting the adjacent water pipes; and
a burner device as claimed in any one of claims 3 to 6, the burner device being arranged so as to inject a mixture into a combustion chamber defined by the water pipe group and the connecting wall, wherein
the plurality of mixture injection bodies of the burner device are arranged concentrically to the water pipe group in an annular manner.

8. The multi-tube once-through boiler device as claimed in claim 7, wherein the plurality of mixture injection bodies arranged in an annular manner are disposed so as to generate swirling flows of the mixture in the same direction.

9. The multi-tube once-through boiler device as claimed in claim 7, wherein the plurality of mixture injection bodies arranged in an annular manner are disposed such that the adjacent mixture injection bodies generate swirling flows of the mixture in opposite directions.

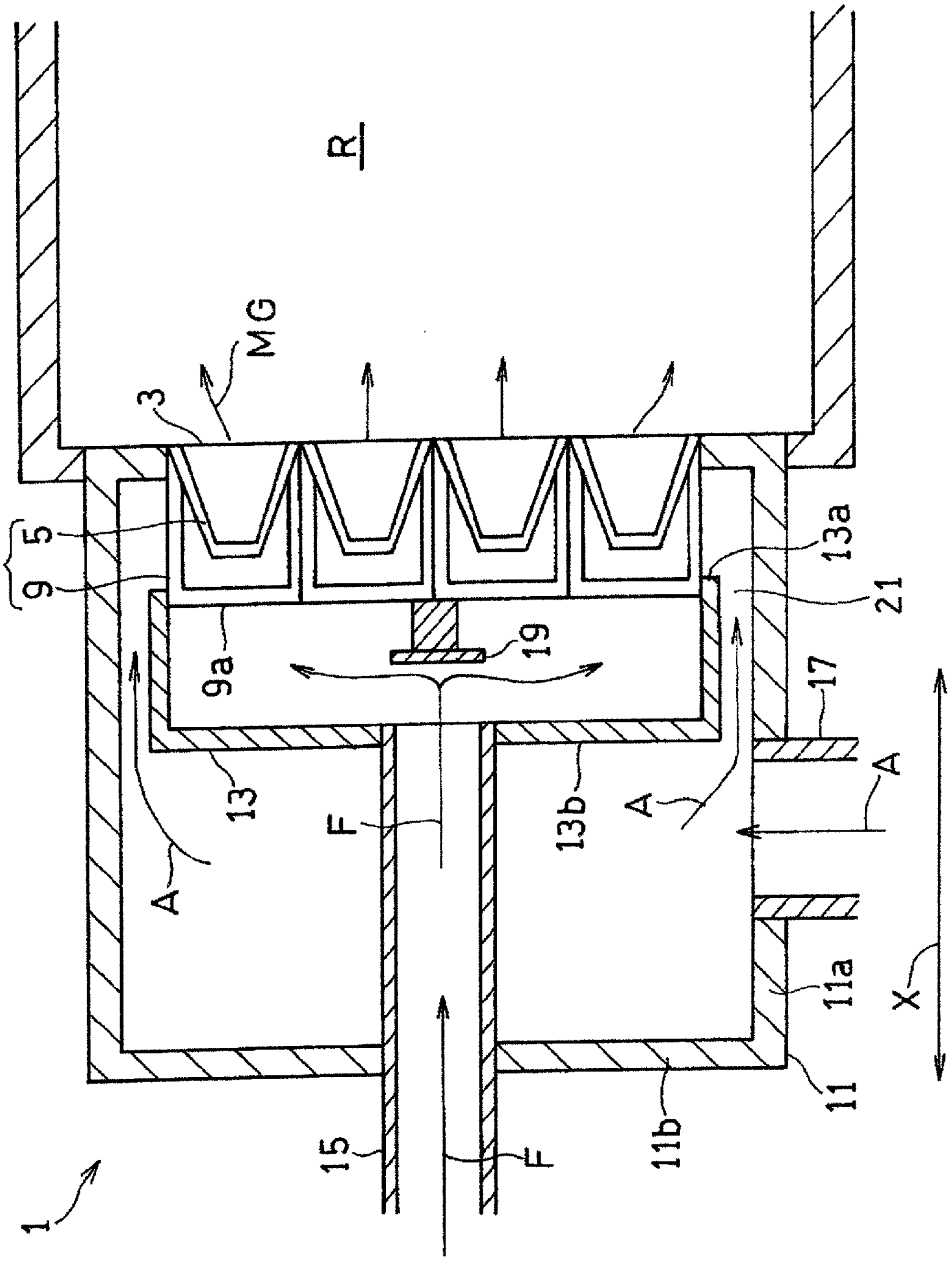


Fig. 1

Fig. 2

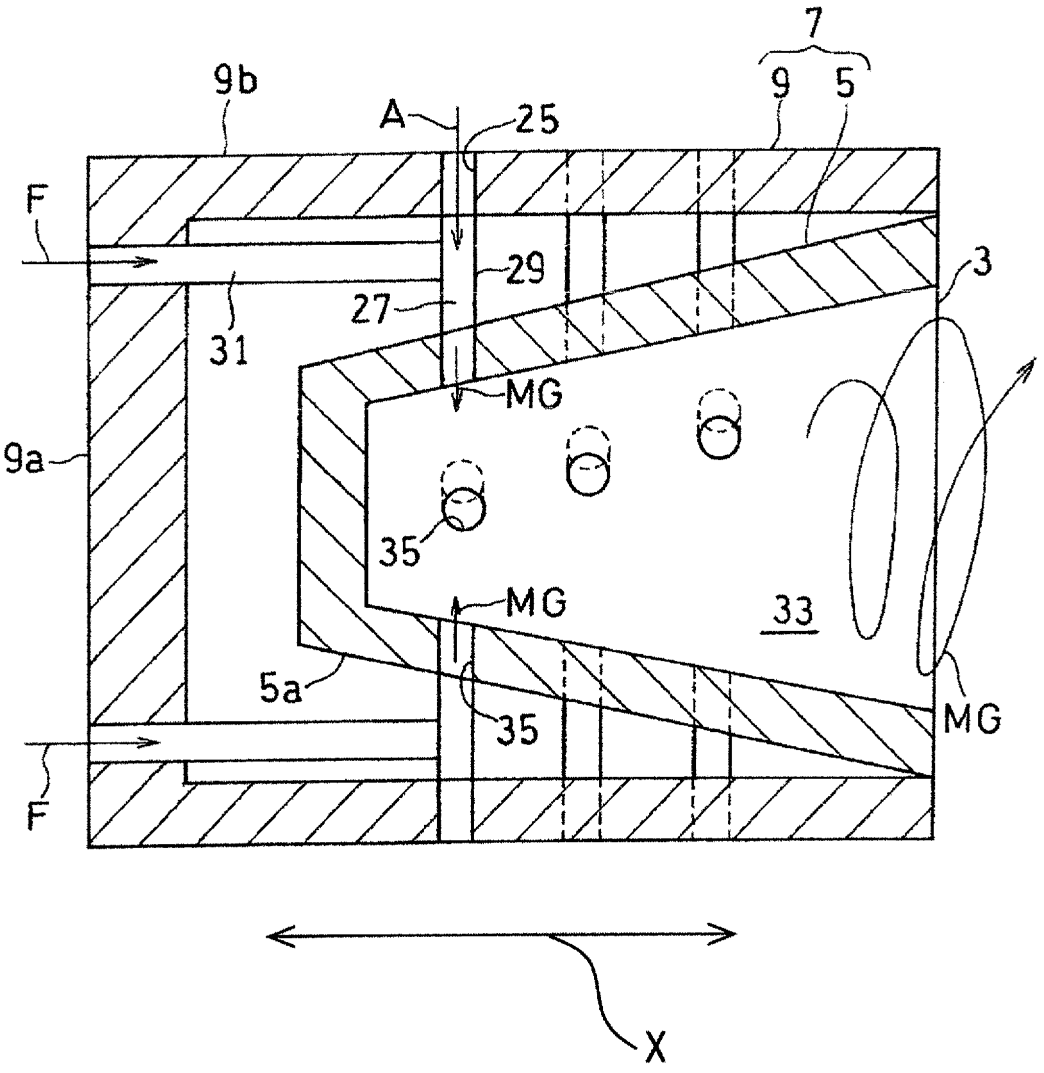
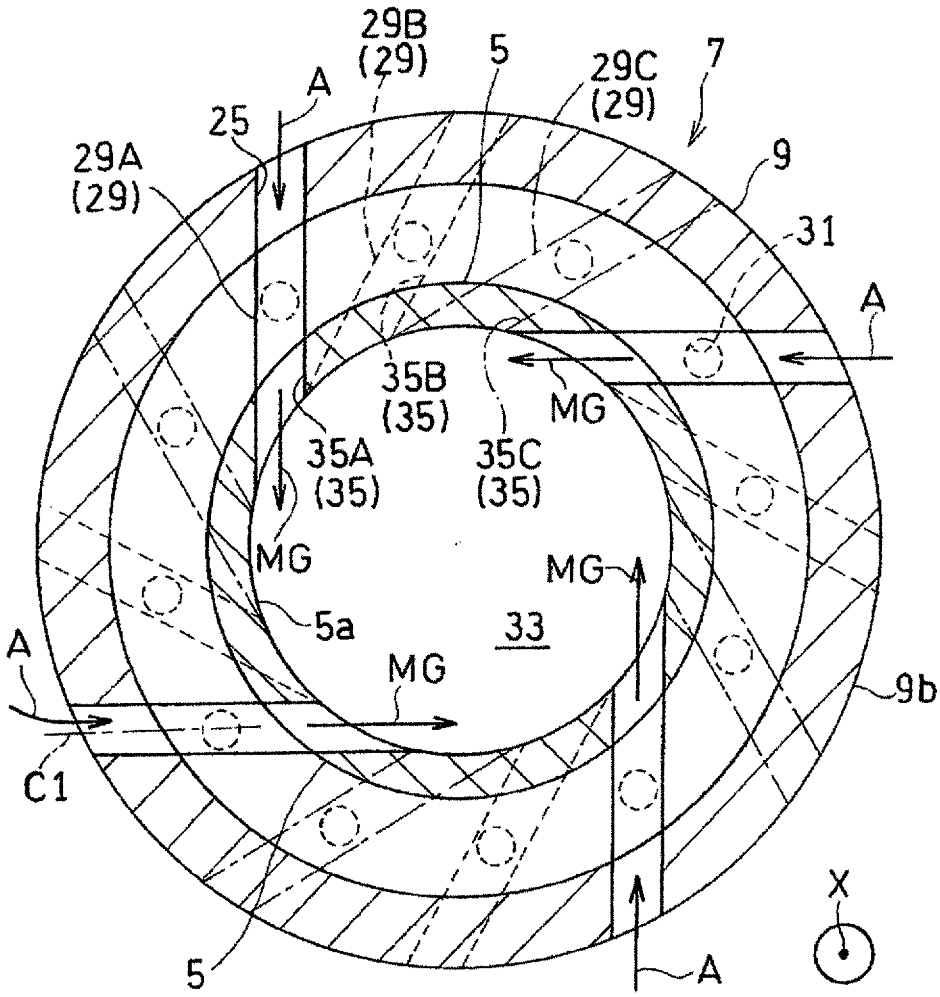


Fig. 3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(29)
5
29C
(29)
7
A
25
29A
(29)
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35C
(35)
MG
MG
5a
33
A
MG
9b
C1
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A

Fig. 4

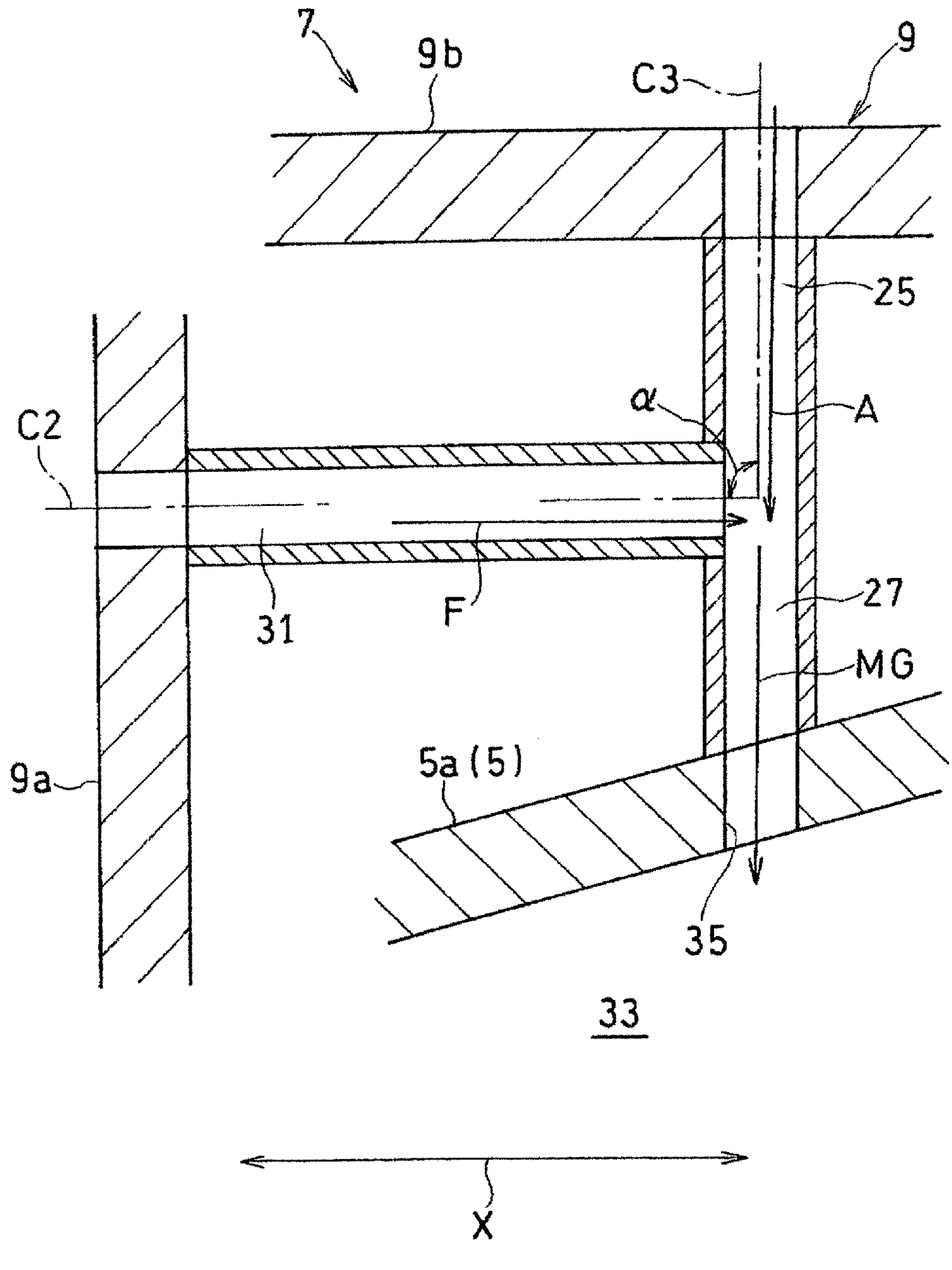


Fig. 5

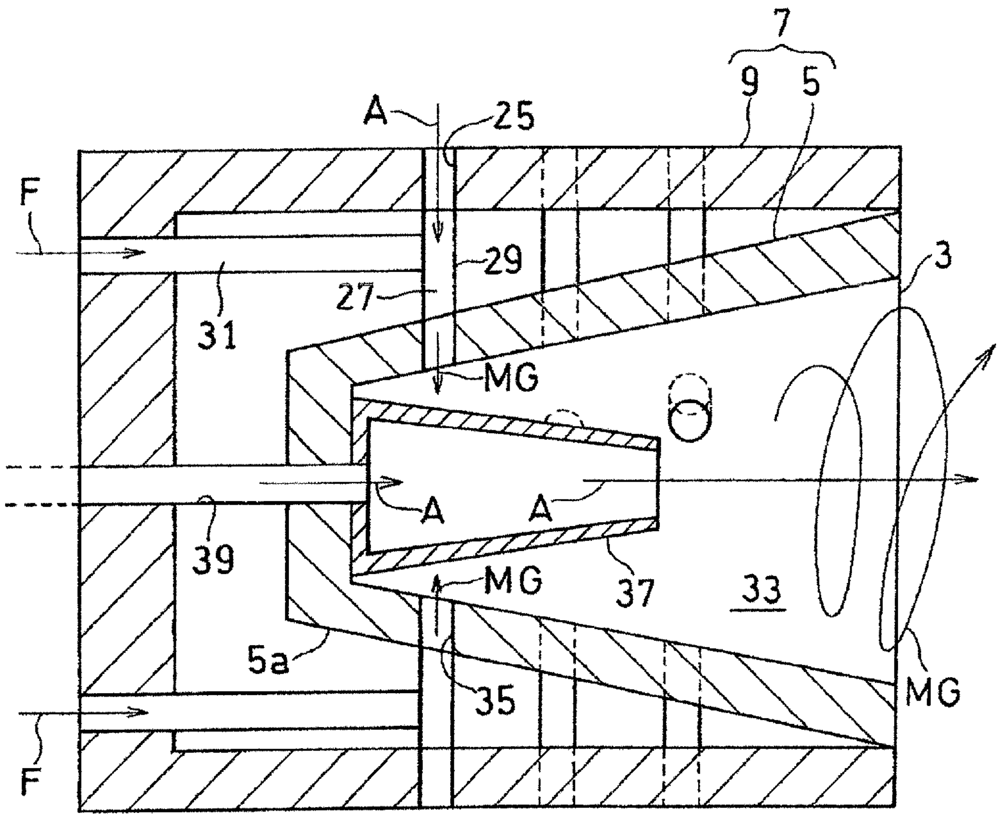


Fig. 6

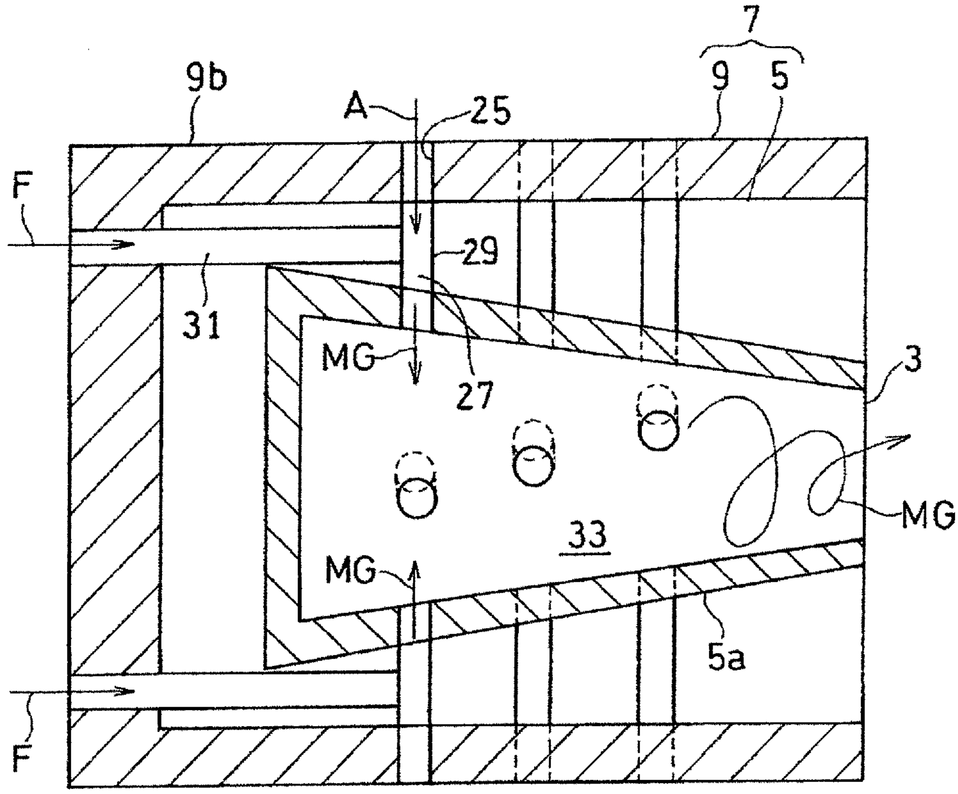


Fig. 7

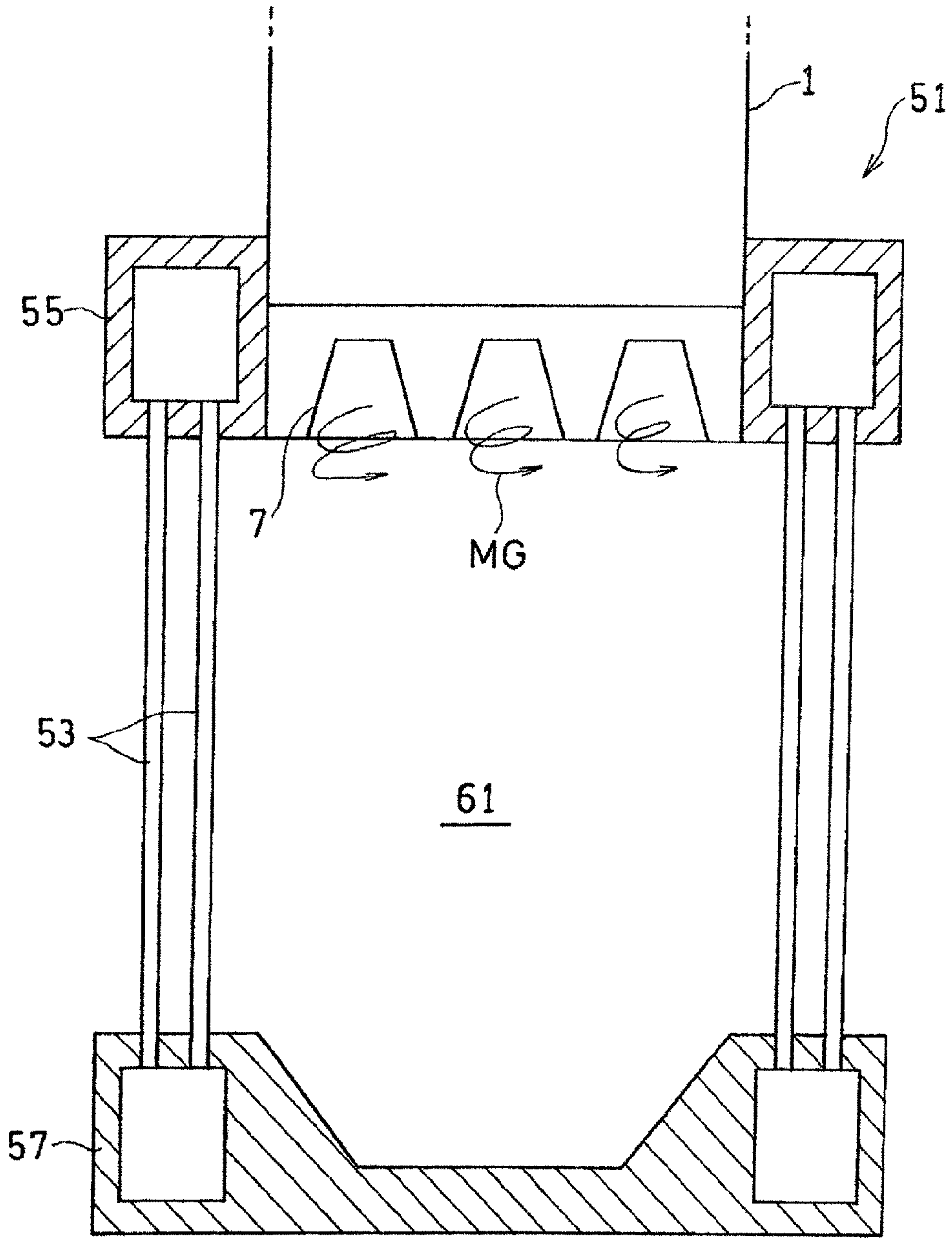


Fig. 8

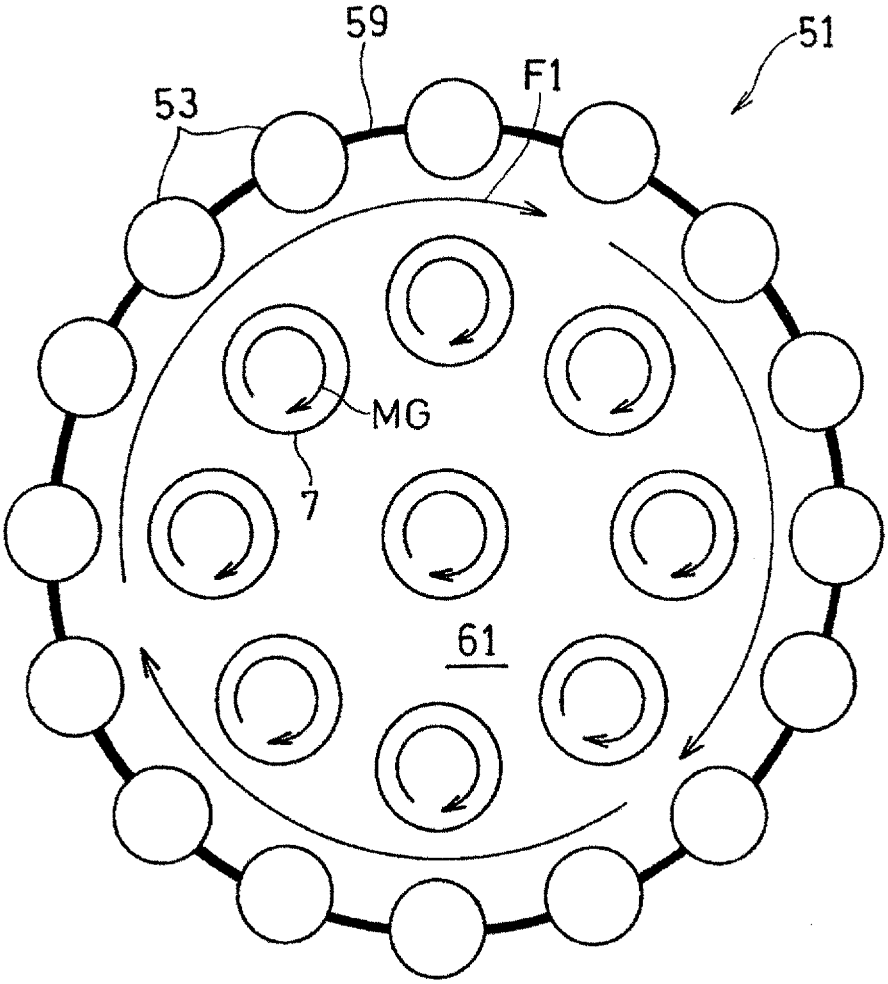
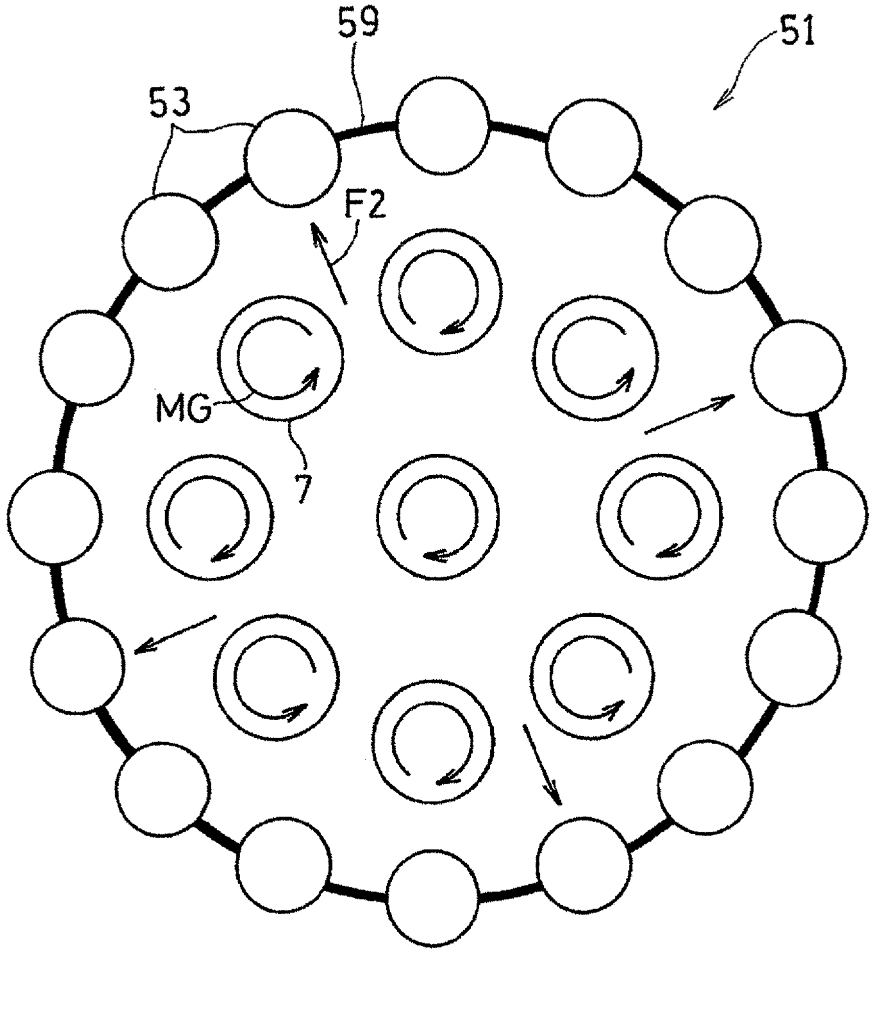


Fig. 9



INTERNATIONAL SEARCH REPORT

International application No. PCT/JP2018/043590

A. CLASSIFICATION OF SUBJECT MATTER
Int.Cl. F23D14/02(2006.01)i, F22B21/06(2006.01)i, F23D14/62(2006.01)i, F23R3/28(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)
Int.Cl. F23D14/00-14/84, F22B21/06, F23R3/00-3/60

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

Published examined utility model applications of Japan	1922-1996
Published unexamined utility model applications of Japan	1971-2019
Registered utility model specifications of Japan	1996-2019
Published registered utility model applications of Japan	1994-2019

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 2013-53814 A (KAWASAKI HEAVY INDUSTRIES, LTD.) 21 March 2013, entire text, all drawings & US 2014/0182294 A1, entire text, all drawings & WO 2013/035474 A1 & WO 2013/035474 A1 & EP 2754963 A1	1-9
Y	JP 2012-107794 A (OSAKA GAS CO., LTD.) 07 June 2012, paragraph [0025], fig. 1-4 (Family: none)	1-9
Y	WO 2012/165614 A1 (KAWASAKI HEAVY INDUSTRIES, LTD.) 06 December 2012, entire text, all drawings & US 2014/0083105 A1, entire text, all drawings & EP 2716976 A1	1-9

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

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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

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
26 February 2019 (26.02.2019)	05 March 2019 (05.03.2019)

Name and mailing address of the ISA/	Authorized officer
Japan Patent Office 3-4-3, Kasumigaseki, Chiyoda-ku, Tokyo 100-8915, Japan	Telephone No.

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INTERNATIONAL SEARCH REPORT

International application No. PCT/JP2018/043590

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 2011-242123 A (GENERAL ELECTRIC CO.) 01 December 2011, entire text, all drawings & US 2011/0277481 A1 & EP 2388525 A2 & CN 102251858 A	6-9
Y	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 5274/1975 (Laid-open No. 86844/1976) (MIURA JAPAN CO., LTD.) 12 July 1976, entire text, all drawings (Family: none)	7-9
Y	JP 2010-256003 A (HITACHI, LTD.) 11 November 2010, paragraphs [0021]-[0026], [0045]-[0051], fig. 1, 8 & US 2010/0251725 A1, paragraphs [0038]-[0043], [0060]-[0066], fig. 1, 8 & EP 2236936 A2 & CN 101858595 A	8-9

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Patent documents cited in the description

- JP 2017229025 A **[0001]**
- US 20120258409 **[0004]**