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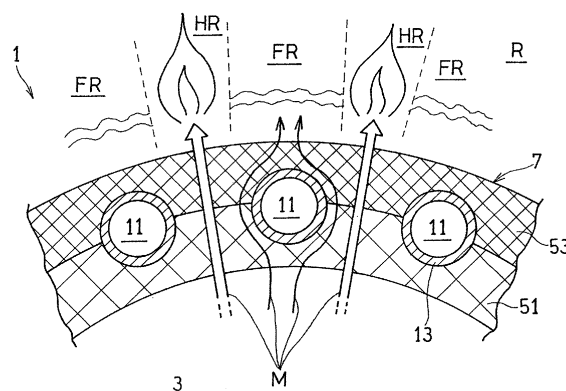
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(54) **BURNER DEVICE**

(57) Provided is a burner device (1) for supplying a premixture (M) of a fuel gas (F) and a combustion-supporting gas (A) into a combustion region (R), the burner device including: a premixing path (3) configured to premix the fuel gas and the combustion-supporting gas; and a porous burner head (7) made of a sintered metal and configured to pass the premixture (M) from the premixing path (3) through the burner head and to inject

the premixture into the combustion region (R), wherein the burner head (7) includes: an inner layer (51) facing the premixing path (3) and made of a sintered metal having a large particle size; and an outer layer (53) facing the combustion region (R) and made of a sintered metal having a smaller particle size than that of the inner layer (51).

Fig. 4



Description

CROSS REFERENCE TO THE RELATED APPLICATION

[0001] This application is based on and claims Convention priority to Japanese patent application No. 2018-028856, filed February 21, 2018, 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] However, where a fuel having high combustion temperature is combusted, NOx is likely to be generated. Also, where a fuel having high combustion speed is combusted, a backfire phenomenon is more likely to occur in which flame generated in a combustion chamber moves back to a burner side. Examples of such fuels having high combustion temperature and high combustion speed may include, e.g., hydrogen and gases with high concentrations of hydrogen.

[0006] An object of the present invention is to provide a burner device capable of suppressing generation of NOx as well as of preventing backfire even where a fuel having high combustion temperature and high combustion speed is used.

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

- a premixing path configured to premix the fuel gas and the combustion-supporting gas; and
- a porous burner head made of a sintered metal and

configured to pass the premixture from the premixing path through the burner head and to inject the premixture into the combustion region, wherein the burner head includes:

- an inner layer facing the premixing path and made of a sintered metal having a large particle size; and
- an outer layer facing the combustion region and made of a sintered metal having a smaller particle size than that of the inner layer.

[0008] According to this configuration, the inner layer having a large pore size because of being made of sintered metal particles having a large particle size rectifies the premixture, causing pressure loss to occur so as to promote premixing. Further, as the premixture passes through the outer layer having a small pore size because of being made of sintered metal particles having a small particle size, the flow speed of the premixture increases such that the premixture is injected into the combustion region at high speed. Thus, it is possible to suppress generation of NOx and to prevent backfire.

[0009] In an embodiment of the present invention, at least a part of a fuel gas supply conduit that defines a fuel gas supply path configured to supply the fuel gas to the premixing path may be disposed in the burner head. According to this configuration, the fuel gas flowing through the fuel gas supply conduit can cool the burner head. This makes it possible to prevent the burner head from burning even when backfire occurs or when flame is formed near the burner.

[0010] In an embodiment of the present invention, the burner head may form a circumferential wall of the burner device having a cylindrical shape, the fuel gas supply conduit may include a plurality of outer peripheral fuel gas supply pipes disposed in the burner head, and the plurality of outer peripheral fuel gas supply pipes may extend parallel to an axial direction of the burner device and be arranged at equal intervals in a circumferential direction of the burner head. According to this configuration, the presence of the fuel gas supply pipes between high speed regions of the premixture where no fuel gas supply pipes are located in an injection surface of the burner head allows flame holding regions where the premixture flows at low speed to be formed in a regular manner. The presence of the flame holding regions restricts circumferential movement of large flame in the high-speed regions so that stable combustion can be achieved in the entire burner head.

[0011] In an embodiment of the present invention, each of the outer peripheral fuel gas supply pipes may have a fuel gas inlet on an upstream side of the burner head in a flow direction of the premixture, the fuel gas supply conduit may further include a central fuel gas supply pipe provided on an axis of the burner device, the central fuel gas supply pipe communicating with the plurality of outer peripheral fuel gas supply pipes at a downstream end

portion of the burner head in the flow direction of the premixture and having a fuel gas outlet to the premixing path on the upstream side of the burner head. This configuration makes it possible to suppress complication of piping structure and increase in dimensions of the entire burner device, even where the outer peripheral fuel supply pipes are disposed in the burner head having a cylindrical shape.

[0012] 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

[0013] 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 broken perspective view illustrating a schematic structure of a burner device according to an embodiment of the present invention;

Fig. 2 is a plan view illustrating an example of a fuel gas introduction part of the burner device shown in Fig. 1;

Fig. 3 is a plan view illustrating an example of a fuel gas introduction part of the burner device shown in Fig. 1;

Fig. 4 is an enlarged cross-sectional view of a burner head of the burner device shown in Fig. 1; and

Fig. 5 is a longitudinal sectional view illustrating a schematic structure of a burner device according to a variant of Fig. 1.

DESCRIPTION OF THE EMBODIMENTS

[0014] 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 a device for supplying a premixture M of a fuel gas and a combustion-supporting gas into a combustion region R. The burner device 1 may be used as a heating device for a power apparatus, such as boilers and gas turbines.

[0015] The fuel gas may be, for example, a fuel that has a high combustion temperature, a high combustion speed 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".

[0016] The burner device 1 as a whole has a substantially cylindrical shape. The burner device 1 has an inner space defining a premixing path 3 in which the fuel F and the air A are premixed. The burner device 1 includes: an injection part 1a (right-side part in Fig. 1) that faces the combustion region R and configured to inject the premixture M into the combustion region R; and a base part 1b (left-side part in Fig. 1) that is configured to introduce the fuel F and the air A into the burner device 1. The injection part 1a and the base part 1b are arranged in an axial direction C of the burner device 1. A flange 5 is provided at an interface between the injection part 1a and the base part 1b of the burner device 1. The flange 5 serves as a connecting part to a heating apparatus in which the burner device 1 is to be used and separates the combustion region R from an introduction space of the fuel F and/or the air A. In the following description, the term "rear side" or the like refers to the side of the combustion region R in the axial direction of the burner device 1 (i.e., the side of the injection part 1a), and the term "front side" or the like refers to the side opposite from the combustion region (i.e., the side of the base part 1b). In this embodiment, the front side corresponds to an upstream side in a flow direction of the premixture M in the premixing path 3, and the rear side corresponds to a downstream side.

[0017] A burner head 7 for injecting the premixture M into the combustion region R forms a circumferential wall of the injection part 1a of the burner device 1. The premixture M in the premixing path 3 passes through the burner head 7 in a radial direction and is injected into the combustion region R. An annular fuel introduction part 9 is provided at a rear end portion of the base part 1b, that is, a portion adjacent to the injection part 1a with the flange 5 interposed therebetween. Outer peripheral fuel supply paths 11 are defined so as to extend parallel to the axis C of the burner device 1 from an inside of the fuel introduction part 9 to an inside of the burner head 7. Each of the outer peripheral fuel supply paths 11 is defined by an outer peripheral fuel supply pipe 13. In this example, a plurality of outer peripheral fuel supply pipes 13 are arranged in a circumferential direction of the burner device 1. The fuel introduction part 9 has a circumferential wall 9a formed with a plurality of fuel introduction openings 15 that extend in the radial direction and allows an outer space of the fuel introduction part 9 and the respective outer peripheral fuel supply paths 11 to communicate with each other. Each of the fuel introduction openings 15 serves as a fuel inlet for each outer peripheral fuel supply path 11, and the fuel F from outside of

the burner device 1 is introduced into the respective outer peripheral fuel supply paths 11 via the respective fuel introduction openings 15.

[0018] The burner device 1 has one end portion that is a rear end portion of the injection part 1a and is closed in a bottomed manner. The rear end portion of the injection part 1a has an inner space which defines a common fuel header chamber 17 communicating with the respective outer peripheral fuel supply paths 11. The burner device 1 has a central part in which a common central fuel supply pipe 21 is disposed such that the central fuel supply pipe 21 communicates with the fuel header chamber 17 and defines a central fuel supply path 19 extending along the axis C. The central fuel supply pipe 21 extends from the fuel header chamber 17 to an inner space of the base part 1b. The fuel F is fed from a fuel feed part 23 located at a downstream end portion (front end portion) of the central fuel supply pipe 21 to the premixing path 3. Thus, in the illustrated example, the outer peripheral fuel supply paths 11, the fuel header chamber 17 and the central fuel supply path 19 form the fuel supply paths 25 to the premixing path 3.

[0019] The burner device 1 has the other end that is a front end portion of the base part 1b and is formed in a bottomless manner. The front end portion of the base part 1b has an opening that serves as an air introduction port 27. The air A introduced from the air introduction port 27 merges into the fuel F at the fuel feed part 23 of the central fuel supply pipe 21.

[0020] In the illustrated example, a rectifying mechanism 29 configured to rectify the flow of the air A to form a uniform flow along the axial direction C is provided at the front end portion of the base part 1b. Specifically, in this example, the rectifying mechanism 29 is provided at an opening part of the air introduction port 27 and includes dividing vanes 31 that equally divide the inner space of the opening part in the circumferential direction and a plurality (two in this example) of annular porous rectifying plates 33 that are disposed downstream of the dividing vanes 31. These components constituting the rectifying mechanism 29 are disposed on an outer periphery of a central support shaft 35 extending forward from the central fuel supply pipe 21. The aspect of the rectifying mechanism 29, however, is not limited to this example. For instance, there may be only one of the dividing vanes 31 and the porous rectifying plates 33 as the rectifying mechanism 33. Also, the rectifying mechanism 29 may be omitted.

[0021] In the illustrated example, the fuel feed part 23 of the central fuel supply pipe 21 is provided as a pipe group 41 including multiple (8 in this example) spoke-like pipes 39 that radially protrude from the central fuel supply pipe 21. As shown in Fig. 2, each of the spoke-like pipes 39 has fuel feed holes 43 that serve as outlets of the fuel F into the premixing path 3 on the rear side thereof. In this example, each of the spoke-like pipes 39 has a plurality of fuel feed holes 43 aligned at equal intervals along a longitudinal direction of the spoke-like pipe 39.

[0022] The fuel feed part 23 of this example includes two pipe groups 41 of the spoke-like pipes 39. As schematically shown in Fig. 3, the two pipe groups are arranged such that each spoke pipe 39A of the first pipe group 41A, which is illustrated with solid lines, is located at a circumferential position centered between circumferential positions of the adjacent spoke pipes 39B, 39B of the second pipe group 41B, which is illustrated with dashed lines.

[0023] In the example shown in Fig. 1, a premixing promoting member 45 configured to promote premixing of the fuel F and the air A is provided on the downstream side (rear side) of the fuel feed part 23 in the premixing path 3. More specifically, in this example, a plurality of (3 in this example) annular porous premixing plates 45 are provided as the premixing promoting member 45. The respective porous premixing plates 45 are disposed on the outer periphery of the central fuel supply pipe 21. The premixing promoting member 45 may be omitted.

[0024] In the present embodiment, however, the structure for supplying gas to the premixing path 3 and the structure for promoting premixing in the premixing path 3 are not limited to the aspects as described above.

[0025] Hereinafter, the structure of the burner head 7 in the present embodiment will be described in detail. The burner head 7 is formed as a porous member made of a sintered metal. Fine pores formed between sintered metal particles provide flow paths for the premixture M from the premixing path 3 to the combustion region R.

[0026] Specifically, as shown in Fig. 4, the burner head 7 includes an inner layer 51 (i.e., layer shown by cross-hatching with wider intervals in Fig. 4) that faces the premixing path 3 and an outer layer 53 (i.e., layer shown by cross-hatching with narrower intervals in Fig. 4) that faces the combustion region R. The outer layer 53 and the inner layer 51 differ in particle sizes of the sintered metal particle forming the respective layers. That is, in this embodiment, the sintered metal particles forming the outer layer 53 have a smaller particle size than that of the sintered metal particles forming the inner layer 51.

[0027] The inner layer 51 has a large pore size, i.e., a large flow path size because it is made of sintered metal particles having a large particle size. Such a flow path in the inner layer 51 makes it possible to rectify the premixture M and promote the premixing. On the other hand, the outer layer 53 has a smaller pore size, i.e., a smaller flow path size than that of the inner layer 51 because it is made of sintered metal particles having a smaller particle size than that of the inner layer 51. As the premixture M passes through the flow path in the outer layer 53, the flow speed of the premixture M increases such that the premixture M is injected into the combustion region R at high speed.

[0028] A metal material to be used as a raw material for the sintered metal for forming the burner head 7 may include, for example, stainless steel, bronze, and nickel. Also, the sintered metal particles forming inner layer 51 may, for example, have a particle size (diameter) from

500 to 1500 μm . The sintered metal particle forming the outer layer 53 may, for example, have a particle size from 50 to 400 μm .

[0029] As described above, the outer peripheral fuel supply pipes (fuel gas supply conduit) 13 that defines the outer peripheral fuel supply paths 11 are disposed in the burner head 7. In the illustrated example, a plurality of the outer peripheral fuel supply pipes 13 are arranged at equal intervals in the circumferential direction of the burner head 7. Also, the outer layer 53 and the inner layer 51 have the substantially the same thickness (radial width). The outer peripheral fuel supply pipes 13 are disposed at an interface part between the outer layer 53 and the inner layer 51.

[0030] The fuel supply pipes such as the outer peripheral fuel supply pipes 13 are disposed in the burner head 7 so that the burner head 7 is cooled by the fuel F flowing in the fuel supply pipes. This cooling makes it possible to prevent the burner head 7 from burning even when a backfire phenomenon occurs or when flame is formed near the burner.

[0031] Further, the outer peripheral fuel supply pipes 13 are arranged at equal intervals in the circumferential direction of the burner head 7 such that the presence of the outer peripheral fuel supply pipes 13 between high-speed regions HR of the premixture M where no outer peripheral fuel supply pipes 13 are located in an injection surface of the premixture M of the burner head 7 allows flame holding regions FR where the premixture M flows at low speed to be formed in a regular manner. The presence of the flame holding regions FR restricts circumferential movement of large flame in the high-speed regions HR so that stable combustion can be achieved in the entire burner head 7.

[0032] In this embodiment, as described above, each of the outer peripheral fuel gas supply pipes 13 has a fuel inlet in the base part 1b located on the upstream side (front side) of the burner head 7 in the flow direction of the premixture M, and the central fuel supply pipe 21 communicates with the plurality of outer peripheral fuel supply pipes 13 at a downstream end portion (rear end portion) of the burner head 7 in the flow direction of the premixture M and has a fuel outlet to the premixing path 3 on the upstream side of the burner head. This configuration makes it possible to suppress complication of piping structure and increase in dimensions of the entire burner device 1, even where the outer peripheral fuel supply pipes 13 are disposed in the burner head 7 having a cylindrical shape.

[0033] The aspect of arrangement of the outer peripheral fuel supply pipes 13 and the central fuel supply pipe 21 in the burner head 7, however, is not limited to this example. Also, it is not essential to provide fuel supply pipes such as the outer peripheral fuel supply pipes 13 in the burner head 7.

[0034] Although, in this embodiment, description is made with reference to an example in which the burner head 7 has a double-layered structure including the outer

layer 53 and the inner layer 51, the burner head 7 is not limited to such a double-layered structure. That is, the burner head 7 may include one or more intermediate layers made of a sintered metal between the outer layer 53 and the inner layer 51. In such a case, the sintered metal forming the intermediate layer(s) may have a particle size that is, for example, larger than that of the sintered metal of the outer layer 53 and smaller than that of the sintered metal of the inner layer.

[0035] As long as the burner head 7 is made of a sintered metal and includes the inner layer 51 made of a sintered metal having a larger particle size and the outer layer 53 made of a sintered metal having a smaller particle size than that of the inner layer 51, the shape of the burner head 7 is not limited to the cylindrical shape as described above. As shown in Fig. 5 as a variant, the burner head 7 may have, for example, a flat plate shape. In this example, a burner head 7 having a flat plate shape and including a premixing injection surface that is perpendicular to the axis C of the burner device 1 is attached at the downstream end portion of the premixing path 3 of the burner device 1. In that case, although not illustrated, fuel supply pipes may also be provided in the burner head 7.

[0036] According to the burner device 1 of the present embodiment shown in Fig. 1 and described above, the inner layer 51 having a large pore size because of being made of sintered metal particles having a large particle size rectifies the premixture M, and thereby premixing is promoted. Further, as the premixture M passes through the outer layer 53 having a small pore size because of being made of sintered metal particles having a small particle size, the flow speed of the premixture M increases such that the premixture M is injected into the combustion region R at high speed. Thus, it is possible to suppress generation of NO_x and to prevent backfire.

[0037] It should be noted that the burner device 1 according to the present embodiment may be applied not only to boiler devices and gas turbines as described above, but also to other types of power apparatuses.

[0038] 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]

[0039]

- | | |
|----|--|
| 1 | Burner device |
| 3 | Premixing path |
| 7 | Burner head |
| 11 | Outer peripheral fuel supply path (fuel gas supply path) |

13	Outer peripheral fuel supply pipe (fuel gas supply conduit)	
19	Central fuel supply path (fuel gas supply path)	
21	Outer peripheral fuel supply pipe (fuel gas supply conduit)	5
25	Fuel supply path (fuel gas supply path)	
51	Inner layer	
53	Outer layer	
A	Air (combustion-supporting gas)	
F	Fuel (fuel gas)	10
M	Premixture	
R	Combustion region	

the fuel gas supply conduit further includes a central fuel gas supply pipe provided on an axis of the burner device, the central fuel gas supply pipe communicating with the plurality of outer peripheral fuel gas supply pipes at a downstream end portion of the burner head in the flow direction of the premixture and having a fuel gas outlet to the premixing path on the upstream side of the burner head.

Claims 15

1. A burner device for supplying a premixture of a fuel gas and a combustion-supporting gas into a combustion region, the burner device comprising:
 - 20 a premixing path configured to premix the fuel gas and the combustion-supporting gas; and
 - a porous burner head made of a sintered metal and configured to pass the premixture from the premixing path through the burner head and to 25 inject the premixture into the combustion region, wherein
 - the burner head includes:
 - 30 an inner layer facing the premixing path and made of a sintered metal having a large particle size; and
 - an outer layer facing the combustion region and made of a sintered metal having a 35 smaller particle size than that of the inner layer.
2. The burner device as claimed in claim 1, wherein at least a part of a fuel gas supply conduit that defines a fuel gas supply path configured to supply the fuel gas to the premixing path is disposed in the burner head. 40
3. The burner device as claimed in claim 2, wherein the burner head forms a circumferential wall of the burner device having a cylindrical shape, 45 the fuel gas supply conduit includes a plurality of outer peripheral fuel gas supply pipes disposed in the burner head, and the plurality of outer peripheral fuel gas supply pipes 50 extend parallel to an axial direction of the burner device and are arranged at equal intervals in a circumferential direction of the burner head.
4. The burner device as claimed in claim 3, wherein 55 each of the outer peripheral fuel gas supply pipes has a fuel gas inlet on an upstream side of the burner head in a flow direction of the premixture,

Fig. 1

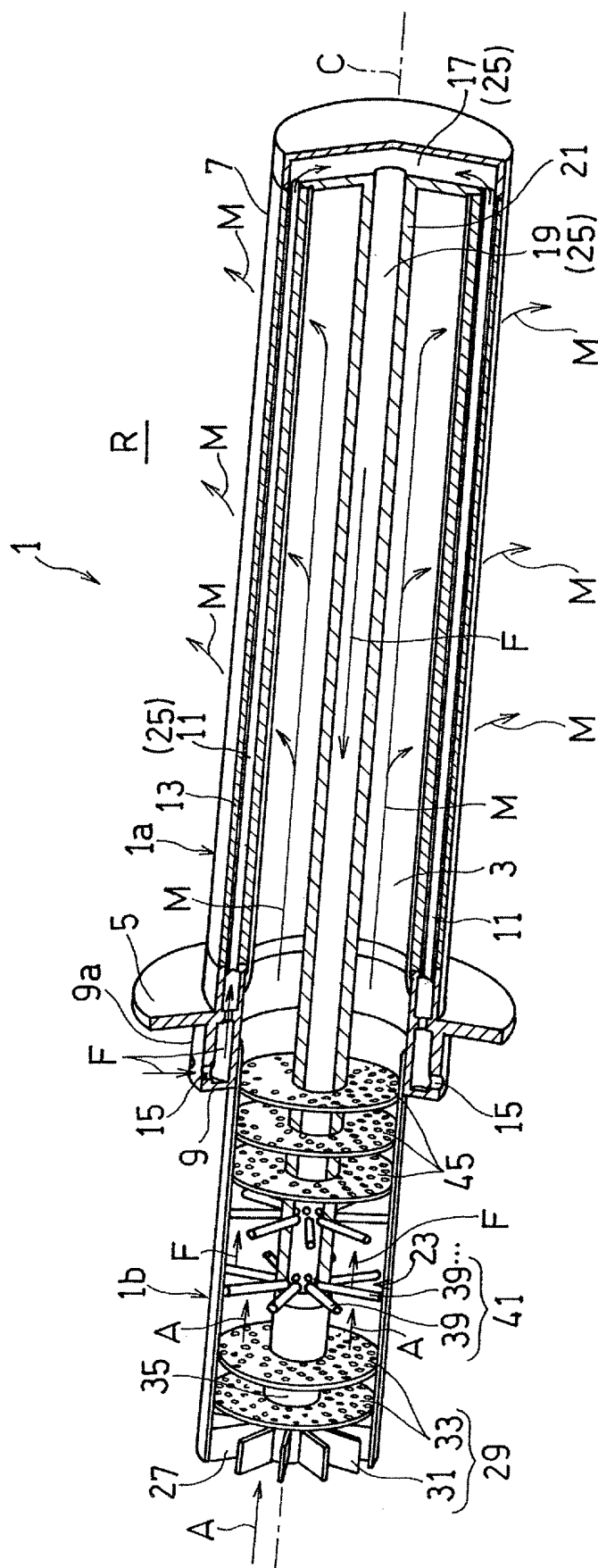


Fig. 2

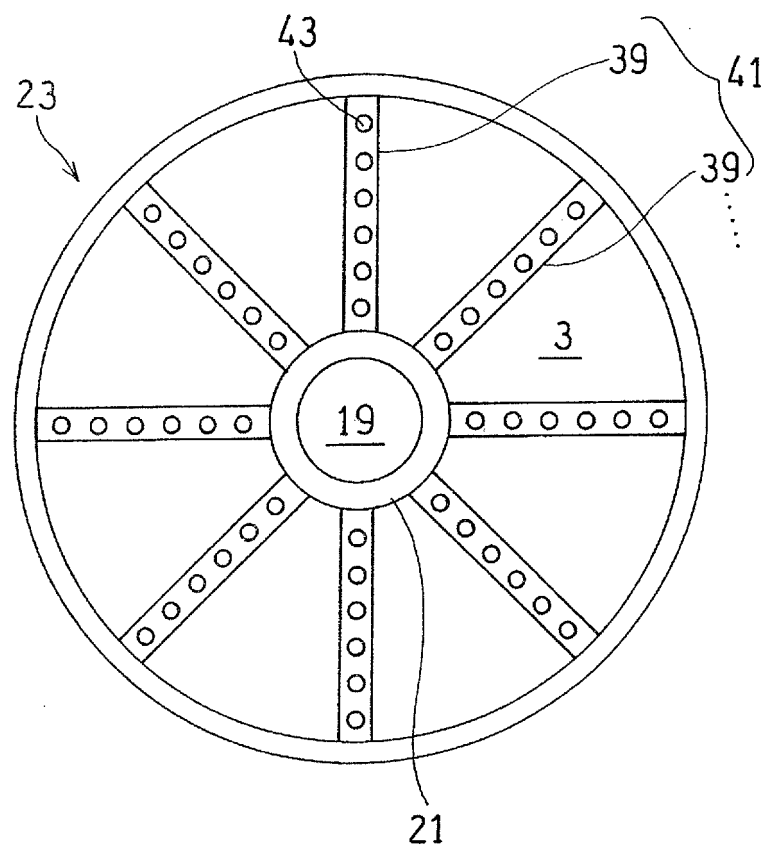


Fig. 3

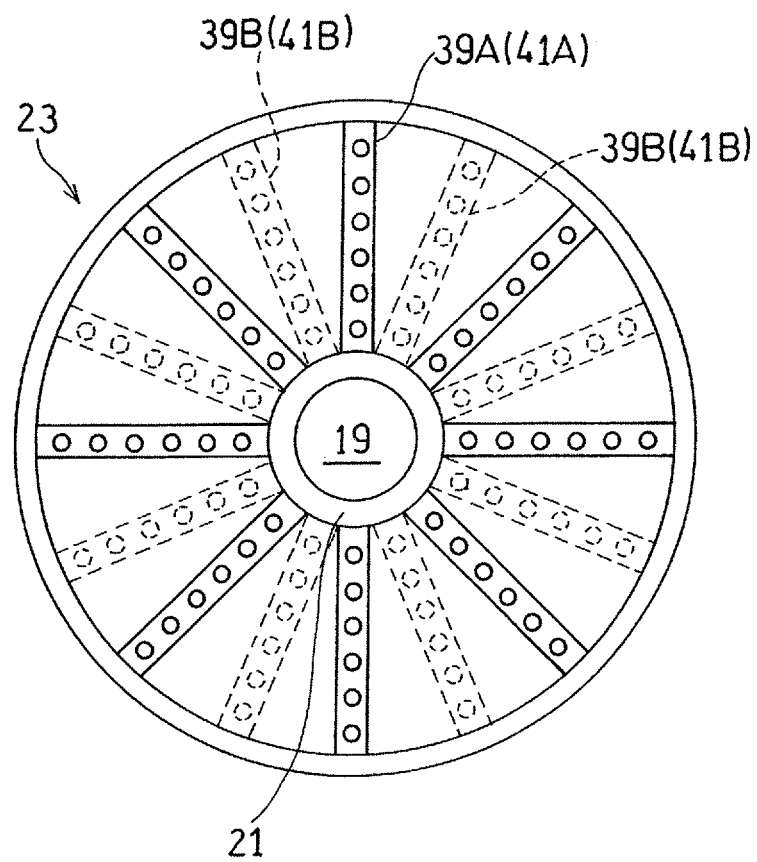


Fig. 4

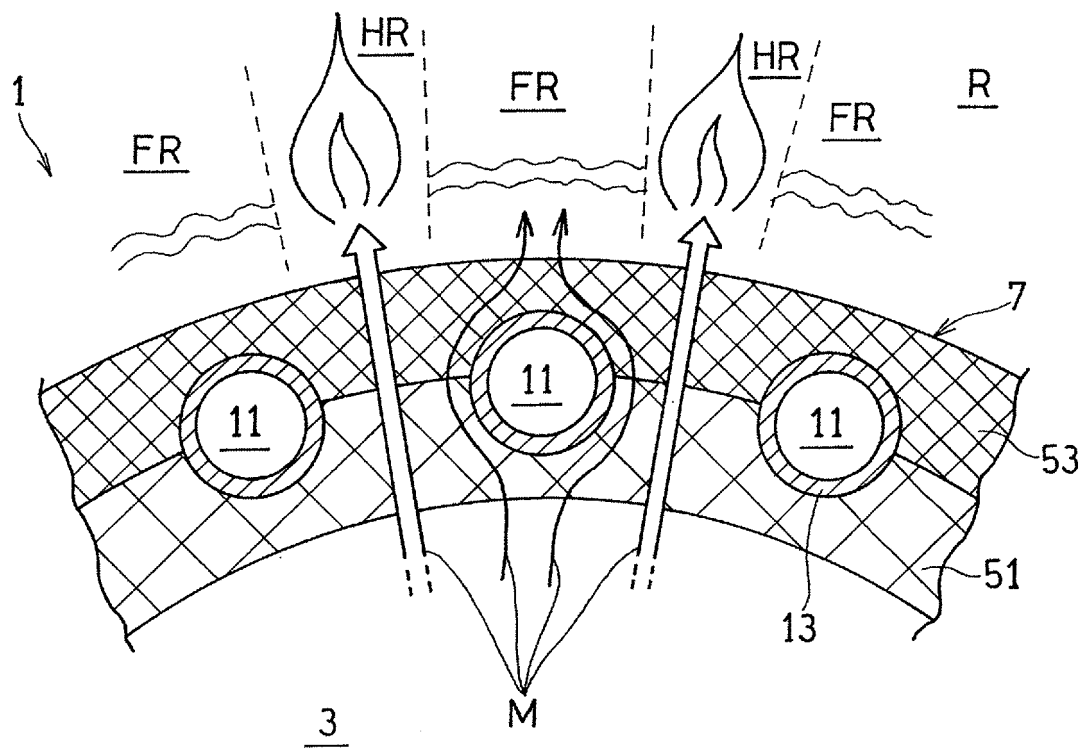
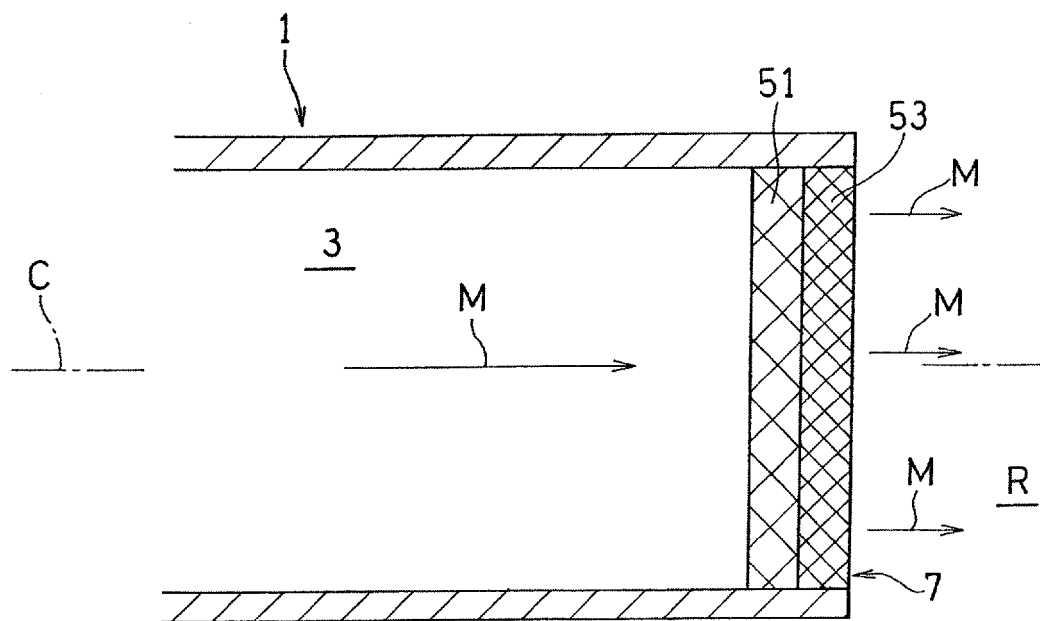


Fig. 5



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2019/003694

A. CLASSIFICATION OF SUBJECT MATTER
Int. Cl. F23D14/16 (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. F23D14/16, F02C7/22, F23R3/00

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.
X	JP 47-40333 A (C.A. STRANDBERG AG) 09 December	1
Y	1972, page 1, lower left column, line 14 to page	2
A	3, upper left column, line 10, fig. 1-5 (Family: none)	3, 4
Y	JP 2013-57448 A (TOHO GAS KK) 28 March 2013,	1
A	paragraphs [0016]-[0038], fig. 1, 2 (Family: none)	2-4
Y	US 2405785 A (GODDARD Robert H.) 13 August 1946,	1
	column 2, line 39 to column 6, line 35, fig. 1, 2 & US 2492569 A	
Y	JP 61-130719 A (TOSHIBA CORP.) 18 June 1986, page	2
	2, upper right column, line 15 to lower left column, line 14, fig. 1 (Family: none)	



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents:

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"&"

document member of the same patent family

Date of the actual completion of the international search
08.03.2019

Date of mailing of the international search report
26.03.2019

Name and mailing address of the ISA/
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Tokyo 100-8915, Japan

Authorized officer

Telephone No.

INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2019/003694

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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REFERENCES CITED IN THE DESCRIPTION

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