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(71) Applicant: **Mitsubishi Heavy Industries, Ltd.**
Tokyo 108-8215 (JP)

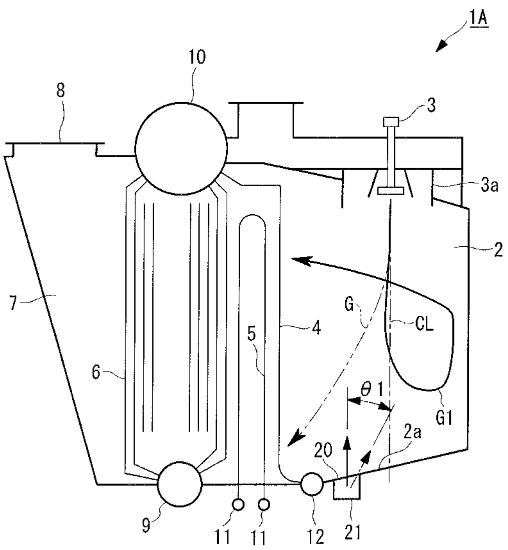
(72) Inventors:
- **IMADA, Junji**
  Nagasaki-shi
  Nagasaki 851-0392 (JP)
- **UCHIDA, Isao**
  Nagasaki-shi
  Nagasaki 850-8610 (JP)

(74) Representative: **Henkel, Feiler & Hänzel**
Patentanwälte
Maximiliansplatz 21
80333 München (DE)

(54) BOILER STRUCTURE FOR VESSEL

(57) Provided is a marine boiler structure that is capable of remedying non-uniformity in corrosion progression by making the temperature distribution of combustion gas that passes through a superheater uniform, and that is also capable of reducing the level of NOx contained in the combustion gas. In a marine boiler structure configured such that combustion gas generated by combustion in a burner 3 flows from a furnace 2 through a superheater 5 and an evaporator tube bundle 6, a bottom air port 20 that supplies part of the combustion air as bottom air from a furnace bottom portion 2a of the furnace 2 is provided, the bottom air port 20 is positioned closer to the superheater 5 relative to a burner center line CL, and an ejecting direction of the bottom air is set within a range inclining in the burner direction from the vertically upward direction.

FIG. 1



EP 2 224 166 A1

Description

Technical Field

[0001] The present invention relates to a marine boiler structure such as a marine boiler, a marine reheat boiler, etc., installed in a vessel.

Background Art

[0002] In comparison with a land boiler used in a power plant, etc., the compactness of the structure is conventionally prioritized in a marine boiler installed in a vessel due to a large constraint on the installation space.
In a conventional marine boiler 1 shown in Fig. 5, one or a plurality of burners 3 are installed at an upper portion of a furnace 2. Combustion gas generated by combusting a fuel in the burners 3 sequentially passes through a front bank tube 4, a superheater 5, and an evaporator tube bundle (rear bank tube) 6, which are disposed downstream of the furnace 2, to carry out heat exchange with fluid such as water, etc. flowing in the tubes. Upon completing heat exchange in this way, the combustion gas passes through an outlet-side gas duct 7 and is ejected to the exterior of the marine boiler 1 from a gas outlet 8. Note that, in the figure, reference sign 9 is a fluid drum, 10 is a vapor drum, and 11 and 12 are headers.
[0003] In the above-described marine boiler 1, it has been proposed (for example, see Patent Citation 1) to provide a rectifying plate on an exit side of the evaporator tube bundle 6, in order to make the combustion gas generated by combustion in the burners 3 uniformly flow through the superheater 5 and the evaporator tube bundle 6.

Patent Citation 1: Japanese Unexamined Patent Application, Publication No. 2002-243106 (see Fig. 1).

Disclosure of Invention

[0004] In the conventional marine boiler structure described above, because the gas temperature distribution of the combustion gas becomes unbalanced, there is a problem in that corrosion concentrates at a lower portion of the superheater 5.
In addition, in a marine boiler 1 whose furnace 2 is small due to size reduction, particularly when the burners 3 are tilted toward the superheater 5, because the flames from the burners 3 are inclined toward the superheater 5, in a region of the superheater 5 close to the flames, the flames are a factor causing accelerated thinning of the tubes constituting the superheater 5 due to high temperature. Furthermore, heat stress in the marine boiler is high due to size reduction, and the problem of increasing level of NOx has been pointed out, reaching about 300 to 400 ppm in some cases, for example, in a marine boiler 1 for oil-fired combustion.
[0005] As indicated by an arrow G in the figure, the above-described imbalance of the combustion gas temperature is caused by the fact that most of the combustion gas flows through the furnace bottom portion of the furnace 2; thus, in the temperature distribution of the combustion gas passing through the superheater 5, the temperature tends to increase toward the center of the lower portion of the superheater. In addition, because there is also a temperature difference in the vapor flowing in the tubes, the temperature increases toward the downstream side where the vapor temperature is higher.
Therefore, in the superheater 5 of the above-described marine boiler 1, corrosion increases toward the lower portion, and, moreover, even in the same lower portion, corrosion is greater at positions where the temperature of vapor flowing in the tubes is higher. In other words, in the superheater 5, there is problem in that corrosion increases in regions of higher temperature.
[0006] Against this background, in a marine boiler structure, in order to prevent or to suppress partial progression of corrosion and thinning (non-uniform corrosion progression) that occurs in tubes constituting a superheater, there is a need to make the temperature distribution of combustion gas passing through the superheater uniform by remedying a temperature distribution in a furnace. In addition, in order to cope with recent environmental problems, there is a need for a marine boiler structure that is capable of reducing the level of NOx contained in the combustion gas.
The present invention has been conceived in light of the above-described circumstances, and an object thereof is to provide a marine boiler structure that is capable of remedying a non-uniform progression of corrosion by making the temperature distribution of combustion gas that passes through a superheater uniform, and that is capable of reducing the level of NOx contained in the combustion gas.
[0007] In order to solve the above-described problems, the present invention employs the following solutions.
A first aspect of a marine boiler structure according to the present invention is a marine boiler structure configured such that combustion gas generated by combustion in a burner flows from a furnace through a superheater and an evaporator tube bundle, including a bottom air port that supplies part of the combustion air as bottom air from a bottom portion of the furnace, wherein the bottom air port is positioned closer to the superheater relative to a burner center line, and an ejecting direction of the bottom air is set within a range inclined in the burner direction from the vertically upward direction.
[0008] With the above-described marine boiler structure of the first aspect, because the bottom air port that supplies part of the combustion air as the bottom air from the furnace bottom portion is provided; the bottom air port is located closer to the superheater relative to the burner center line; and the ejecting direction of the bottom air is set within the range inclined in the burner direction from the vertically upward direction, it is possible to change a flow pattern of the combustion gas in the fur-

nace with the flow of the bottom air. That is, because the flow of the combustion gas heading toward the superheater from the furnace bottom portion is initially pushed in an opposite direction from the superheater due to the flow of the bottom air, flow concentrating on a furnace bottom portion side can be eliminated, and the combustion gas can flow substantially uniformly toward the superheater. In addition, injecting the bottom air in this way constitutes a two-stage injection of the combustion air, which is effective in reducing NOx in the combustion gas.

[0009] In this case, in order to simultaneously achieve size reduction of the furnace, it is preferable that the combustion air used as the bottom air be about 30 % or less of the total amount of air.

In addition, it is desirable that the ejecting direction of the bottom air ports be set within in a range between the vertically upward direction (0 degree) and about 45 degrees in the burner direction.

Furthermore, for the bottom air, it is desirable to ensure a high flow rate of about 20 to 100 m/s by 1) setting the number of bottom air ports to be minimally equal to the number of burners, or 2) by using a continuous slit-shape.

[0010] A second aspect of a marine boiler according to the present invention is a marine boiler structure configured such that combustion gas generated by combustion in a burner flows from a furnace through a superheater and an evaporator tube bundle, including a side air port that supplies part of the combustion air as side air from an upper portion of the furnace, wherein the side air port is positioned closer to the superheater relative to a burner center line, and an ejecting direction of the side air is set within the range inclined toward both the superheater and the burner, with reference to the vertically downward direction.

[0011] With the above-described marine boiler structure of the second aspect, because the side air port that supplies part of the combustion air as the side air from the upper portion of the furnace is provided; the side air port is located closer to the superheater relative to the burner center line; and the ejecting direction of the side air is set, with reference to the vertically downward direction, within the range inclined toward both the superheater and the burners, it is possible to change a combustion zone and a flow pattern of the combustion gas in the furnace with the flow of the side air. That is, because the combustion zone in the furnace is adjustable with the flow direction of the side air, for example, when the combustion zone is moved in a direction away from the superheater, flames also move away from the superheater, thus changing the flow pattern of the combustion gas.

[0012] In addition, by appropriately adjusting the flow direction of the side air, even in a furnace of a compact marine boiler, flames can be prevented from inclining toward the superheater.

Furthermore, by injecting the side air, it is possible to adjust the degree of spreading of the combustion air, which is effective in reducing NOx in the combustion gas. Moreover, because the injection of the side air forms an air curtain at an upper portion on the superheater tube side, a bypass flow at the upper portion of the superheater can be reduced.

[0013] In this case, in order to simultaneously achieve size reduction of the furnace, it is preferable that the combustion air used as the side air be about 30 % or less of the total amount of air.

In addition, it is desirable that the ejecting direction of the side air ports be set within a range of about 30 degrees each in the superheater direction and the burner direction (-30 degrees to +30 degrees) centered around a vertically downward direction (0 degree).

[0014] Furthermore, it is preferable that the side air ports of the present invention be arranged in the same blast box as the burners.

In this case, with respect to the number and the arrangement of the side air ports, three possible cases are 1) to arrange them directly adjacent to the burners in the same number as the number of burners; 2) to arrange them between the burners in a number one less than the number of burners; or 3) to arrange them adjacent to the burners by providing slits in a continuous port; and, for the side air, it is desirable to ensure a high flow rate of about 20 to 60 m/s.

[0015] According to the present invention described above, in a furnace of a marine boiler, the flow pattern of the combustion gas concentrated at a bottom portion of the furnace can be changed with the influence of bottom air and side air. As a result, because the combustion gas temperature at a superheater inlet is made uniform and the conventional temperature imbalance can be eliminated or reduced, it is possible to provide a marine boiler structure in which non-uniform corrosion progression concentrated at a lower portion of the superheater is remedied.

In addition, because the use of the bottom air realizes two-stage injection of the combustion air, and because the injection of the side air makes the degree of spreading of the combustion air adjustable, a marine boiler structure in which the level of NOx contained in the combustion gas is reduced is realized.

Brief Description of Drawings

[0016]

[Fig. 1] Fig. 1 is a longitudinal sectional view showing a first embodiment of a marine boiler structure according to the present invention.

[Fig. 2A] Fig. 2A is a plan view of a relevant portion of Fig. 1, showing an example arrangement of bottom air ports.

[Fig. 2B] Fig. 2B is a plant view of a relevant portion, showing a modification of Fig. 2A.

[Fig. 3] Fig. 3 is a longitudinal sectional view showing a second embodiment of a marine boiler structure according to the present invention.

[Fig. 4A] Fig. 4A is a plan view of a relevant portion of Fig. 3, showing an example arrangement of side air ports.

[Fig. 4B] Fig. 4B is a plan view of a relevant portion, showing a first modification of Fig. 4A.

[Fig. 4C] Fig. 4C is a plan view of a relevant portion, showing a second modification of Fig. 4A.

[Fig. 5] Fig. 5 is a longitudinal sectional view showing a conventional marine boiler structure.

Explanation of Reference:

[0017]

1A, 1B: marine boiler
2: furnace
3: burner
5: superheater
6: evaporator tube bundle
20, 20A: bottom air port
30, 30A: side air port

Best Mode for Carrying Out the Invention

[0018] An embodiment of a marine boiler structure according to the present invention will be described below based on the drawings.

In a marine boiler 1A shown in Fig. 1, one or a plurality of burners 3 are installed in a blast box 3a at an upper portion of a furnace 2. The burners 3 combust fuel supplied using combustion air and supply generated combustion gas to a downstream heat exchanger.

The combustion gas generated in the burners 3 passes through a heat exchanger disposed downstream of the furnace 2 where it performs heat exchange. In a configuration shown in the figure, a front bank tube 4, a superheater 5, and an evaporator tube bundle (rear bank tube) 6 are arranged in the heat exchanger in that order, and the combustion gas is heated through heat exchange with fluid, such as water, etc., that is flowing through individual tubes of the heat exchanger. Upon completing heat exchange in this way, the combustion gas passes through an outlet side gas duct 7 and is ejected to the exterior of the marine boiler 1 from a gas outlet 8. Note that, in the figure, reference sign 9 is a fluid drum, 10 is a vapor drum, and 11 and 12 are headers.

First Embodiment

[0019] As shown in Figs. 1 and 2, in a marine boiler structure of this embodiment, bottom air ports 20 that supply part of combustion air as bottom air from a furnace bottom portion 2a of a furnace 2 are provided in a marine boiler 1A which is configured so that combustion gas generated by combustion in burners 3 flows from the furnace 2, passing through a superheater 5 and an evaporator tube bundle 6. The bottom air ports 20 are located closer to the superheater 5 relative to center lines CL of the burners 3, and in addition, an ejecting direction of the bottom air jetted from the bottom air ports 20 is set within an angular range 81 inclined in the direction of the burners 3 from a vertically upward direction.

Note that, the above-described bottom air ports 20 are connected to bottom air ducts 21 formed in the exterior of the furnace 2, and the combustion air is supplied through these ducts.

[0020] The bottom air ports 20 are provided, for example as shown in Fig. 2A, in the same number as the number of burners 3, thereby setting the flow rate at which the bottom air is jetted high. That is, the bottom air ports 20 are arranged in positions directly adjacent to the burners 3 in plan view so that part of the combustion air used as the bottom air is injected while maintaining its flow rate at a high flow rate at or above a predetermined value. In consideration of good combustion, etc. in the furnace 2, it is preferable that the amount of the bottom air usable here be about 30 % or less of all combustion air. Note that, in order to adequately affect the flow pattern of the combustion gas, described later, for the flow rate of the bottom air injected from the bottom air ports 20, it is desirable to ensure a high flow rate of about 20 to 100 m/s, depending on various conditions, such as the size of the furnace 2, etc.

[0021] It is desirable that the ejection direction of the bottom air ports 20, at positions closer to the superheater 5 than to the burners 3, be set within a range from 0 degree, i.e., the vertically upward direction, to about 45 degrees toward the burner direction. That is, it is desirable that the angular range θ1 in Fig. 1 be set within a range approximately between 0 and 45 degrees, so that the flow of bottom air can efficiently push the flow of combustion gas (see two-dot chain-line arrow G in the figure), which tends to concentrate at the furnace bottom portion 2a, in a direction away from the superheater 5.

[0022] In a marine boiler structure provided with the bottom air ports 20 described above, the flow pattern of the combustion gas in the furnace 2 can be changed with the flow of bottom air. That is, as shown by a solid-line arrow G1 in the figure, the flow of combustion gas heading toward the superheater 5 from the furnace bottom portion 2a is initially pushed in the opposite direction from the superheater 5 due to the flow of bottom air flowing upward. Because of this, with the flow toward the furnace bottom portion 2a side partially prevented, the combustion gas flows spiraling upward in the furnace 2; therefore, a flow that is conventionally concentrated at the furnace bottom portion 2a side is eliminated, and the combustion gas flows substantially uniformly toward the superheater 5.

[0023] In other words, by injecting the bottom air described above, the flow pattern of the combustion gas is altered, and the combustion gas flowing from the furnace bottom portion 2a into the superheater 5 is initially pushed to the opposite side from the superheater 5, thereby being uniformly pushed towards the superheater 5 side. Accordingly, at a lower portion of the superheater at the furnace bottom portion 2a side of the superheater 5, a high temperature gas region where corrosion is accelerated is reduced.

In addition, due to the effect of collision between the combustion gas and the opposing flow of the bottom air injected upward, mixing of the combustion gas is enhanced, and an advantage is also afforded in that the temperature imbalance at an inlet as a whole is reduced in the superheater 5.

[0024] In the furnace 2 of the marine boiler 1A, because the combustion gas temperature at the inlet of the superheater 5 is made uniform as described above, the conventional temperature imbalance can be eliminated or reduced. Therefore, it is possible to remedy the non-uniform corrosion progression concentrated at the lower portion of the superheater 5 and to improve durability and reliability.

In addition, because the use of the bottom air described above means that the combustion air for the burners 3 is injected in two stages, it also becomes possible to reduce the level of NOx contained in the combustion gas.

[0025] Incidentally, although the number of bottom air ports 20 is set equal to the number of burners 3 in the above-described embodiment, ports equal to or greater in number than the number of the burners may be provided in order to ensure a high flow rate of the bottom air to be injected. In addition, as in a modification shown in Fig. 2B, continuous slit-like bottom air ports 20A in which partitions are appropriately inserted may be used.

Second Embodiment

[0026] A second embodiment of a marine boiler structure according to the present invention will be described based on Figs. 3 and 4A. Note that, identical reference signs are assigned to components similar to those of the above-described embodiment, and detailed descriptions thereof will be omitted.

In this embodiment, a marine boiler 1B is provided with side air ports 30 that supply part of the combustion air as side air from the upper portion of the furnace 2. The side air ports 30 are provided in the same blast box 3a as the burners 3.

The side air ports 30 described above are arranged closer to the superheater 5 relative to the burner center line CL, and the ejecting direction of the side air is adjustably set within an angular range $\pm\theta2$ that inclines toward both the superheater 5 and the burners 3, with reference to the vertically downward direction. That is, it is preferable that $\theta2$ in this case be set to about 30 degrees, and therefore, it is desirable to provide an adjusting mechanism with which the side air ports 30 are tiltable within an angular range of ±30 degrees in the ejecting directions.

[0027] In addition, the number of side air ports 30 provided in the same blast box 3a as the burners 3, for example, as shown in Fig. 4A, is the same as the number of burners 3. This is to set the jetted flow rate high for the side air that uses part of the combustion air. That is, in the example shown in the figure, the side air ports 30 are arranged in positions directly adjacent to each burner 3 so that the side air is injected while maintaining the flow rate at a high flow rate at or above a predetermined value. In consideration of good combustion, etc. in the furnace 2, it is preferable that the amount of the bottom air usable here be about 30 % or less of all combustion air. Note that, in order to adequately affect the flow pattern of the combustion gas, described later, for the flow rate of the side air injected from the side air ports 30, it is desirable to ensure a high flow rate about of 20 to 60 m/s, depending on various conditions, such as the size of the furnace 2, etc.

[0028] With such a configuration, it is possible to change a combustion zone formed in the furnace 2 and the flow pattern of the combustion gas with the flow of the side air injected from the side air ports 30. That is, because the combustion zone formed in the furnace 2 becomes adjustable in accordance with the flow direction of the injected side air, for example, when the ejecting direction of the side air is inclined toward the burners 3, the combustion zone in the furnace 2 can be moved in a direction away from the superheater 5.

As a result of this, the flames that combust the fuel injected from the burners 3 are also formed at positions away from the superheater 5. Therefore, the flow pattern of the combustion gas, not to mention the direct influence of the flames on the superheater 5, can be changed as shown by arrow G2 in the figure. That is, because the flow of the combustion gas initially forms a flow directed in a direction away from the superheater 5 due to the influence of the side air, the conventional flow concentrated at the furnace bottom portion 2a is remedied, thereby being changed so as to substantially uniformly flow over the entire surface of the superheater 5. In other words, it is possible to reduce the temperature imbalance generated at the inlet of the superheater 5 by altering the flow pattern of the combustion gas with the injection of the above-described the side air.

[0029] In addition, because it becomes possible to appropriately adjust the flow direction of the side air by changing the inclination angle $\theta2$ of the side air ports 30 described above, the flames can be prevented from inclining toward the superheater 5 in the furnace 2 of the compact marine boiler 1B. As a result, it is possible to eliminate the problem of accelerated thinning of tubes of the super heater 5 due to the direct influence of the flames inclined in a direction toward the tubes.

Furthermore, because the degree of spreading of the combustion air can be adjusted by injecting the side air from the side air ports 30 described above, it also becomes possible to reduce NOx in the combustion gas.

[0030] Moreover, the injection of the side air described above can form, at the tube side of the superheater 5, an air curtain with the side air at the upper portion thereof. The formation of the air curtain as described above can reduce a bypass flow of the combustion gas that flows so as to pass through the upper portion of the superheater 5. That is, because the amount of combustion gas that performs heat exchange by passing through the superheater 5 increases, it is also effective for improving the efficiency of the marine boiler 1B.

[0031] Incidentally, in the embodiment described above, with respect to the number and arrangement of the side air ports 30, a number equal to the number of burners 3 is arranged directly adjacent thereto; however, the number and the arrangement are not limited thereto. In the first modification shown in Fig. 4B, the number of side air ports 30 is one less than the number of burners 3, and the side air ports 3 are each arranged between the adjacent burners 3 and 3. In addition, in the second modification shown in Fig. 4C, the configuration is such that a continuous side air port 30A is sectioned by appropriately providing slits 31 and is arranged adjacent to the burners 3. In these modifications, a high flow rate of about 20 to 60 m/s is also ensured in the jetted side air.

[0032] In this way, according to the marine boiler structure of the present invention described above, in the marine boilers 1A and 1B, the flow pattern of the combustion gas concentrated at the furnace bottom portion 2a can be changed in a controlled manner with the influence of the bottom air or the side air. As a result, at the inlet of the superheater 5, the conventional temperature imbalance is eliminated or reduced, promoting a uniform of the combustion gas temperature, and therefore, non-uniformity in the marine boiler structure is remedied with respect to the progression of tube corrosion concentrated at the lower portion of the superheater 5.

In addition, because the combustion air is injected in two stages with the use of the bottom air, and because the injection of the side air makes the degree of spreading of the combustion air adjustable, in both cases, the marine boiler structure has a reduced level of NOx in the combustion gas.

[0033] That is, in the marine boiler structure of the present invention, it is possible to reduce the imbalance occurring in the inlet temperature of the superheater 5 by controlling the combustion state of the flames and the gas flow pattern through changing the injection methods of the combustion air, and to reduce NOx by injecting the combustion air in stages.

Note that, the present invention is not limited to the embodiments described above, and appropriate alterations are possible without departing from the gist of the present invention; for example, it is also applicable to a marine reheat boiler provided with reheat burners and a reheat furnaces downstream of an evaporator tube bundle 6.

Claims

1. A marine boiler structure configured such that combustion gas generated by combustion in a burner flows from a furnace through a superheater and an evaporator tube bundle, comprising:

   a bottom air port that supplies part of the combustion air as bottom air from a bottom portion of the furnace,
   wherein the bottom air port is positioned closer to the superheater relative to a burner center line, and an ejecting direction of the bottom air is set within a range inclined in the burner direction from the vertically upward direction.

2. A marine boiler structure configured such that combustion gas generated by combustion in a burner flows from a furnace through a superheater and an evaporator tube bundle, comprising:

   a side air port that supplies part of the combustion air as side air from an upper portion of the furnace,
   wherein the side air port is positioned closer to the superheater relative to a burner center line, and an ejecting direction of the side air is set, with reference to the vertically downward direction, within the range inclined toward both the superheater and the burner.

3. A marine boiler structure according to Claim 2, wherein the side air port is arranged in the same blast box as the burner.

FIG. 1

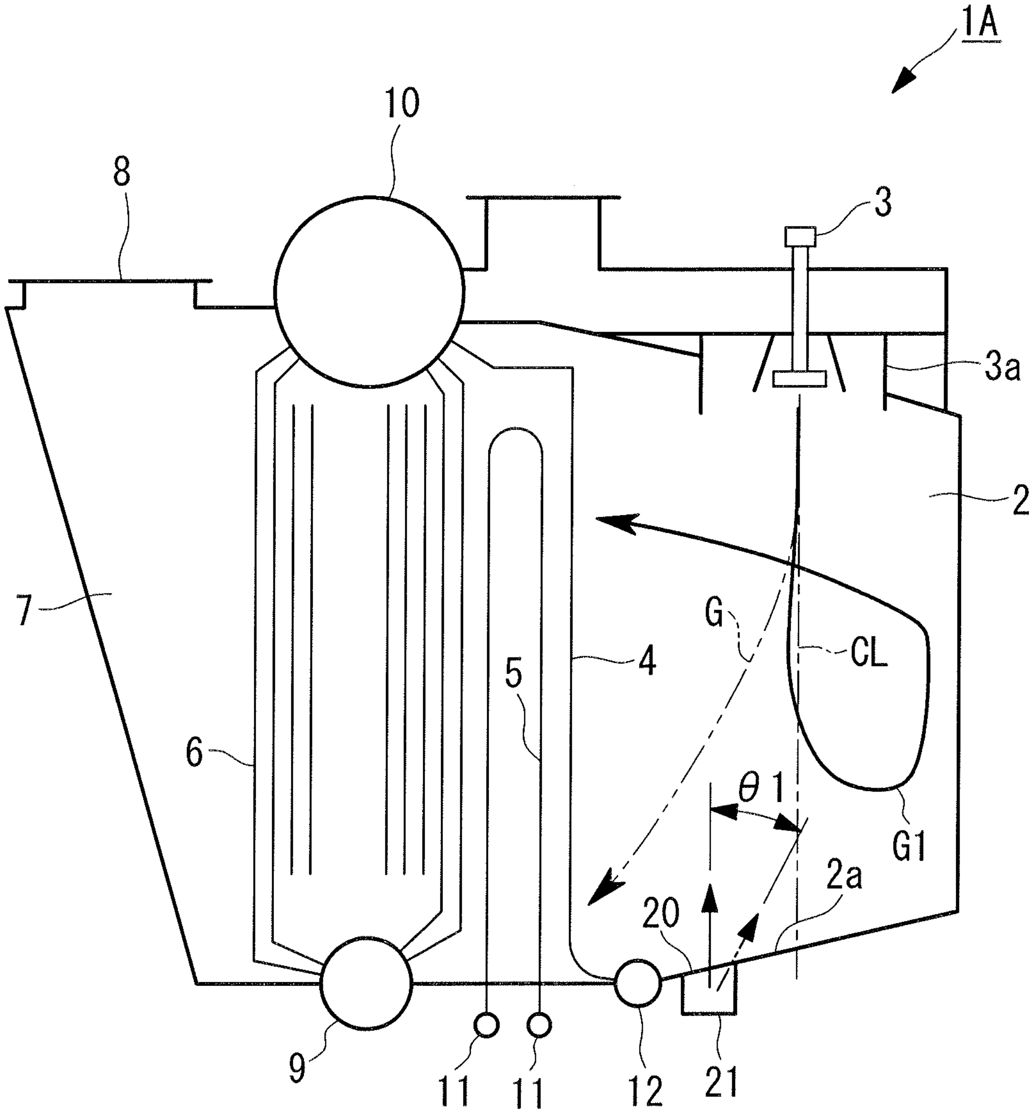


FIG. 2A

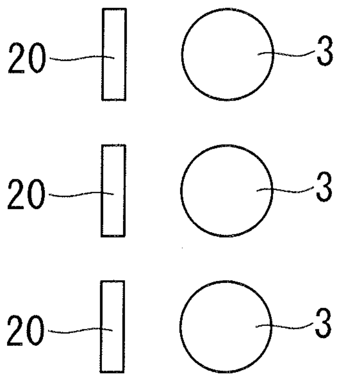


FIG. 2B

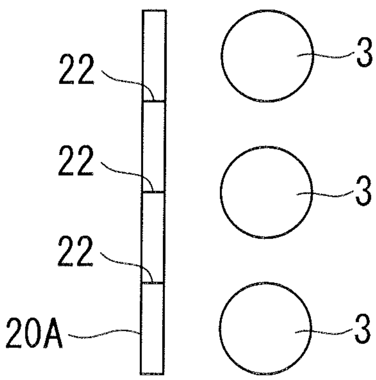


FIG. 3

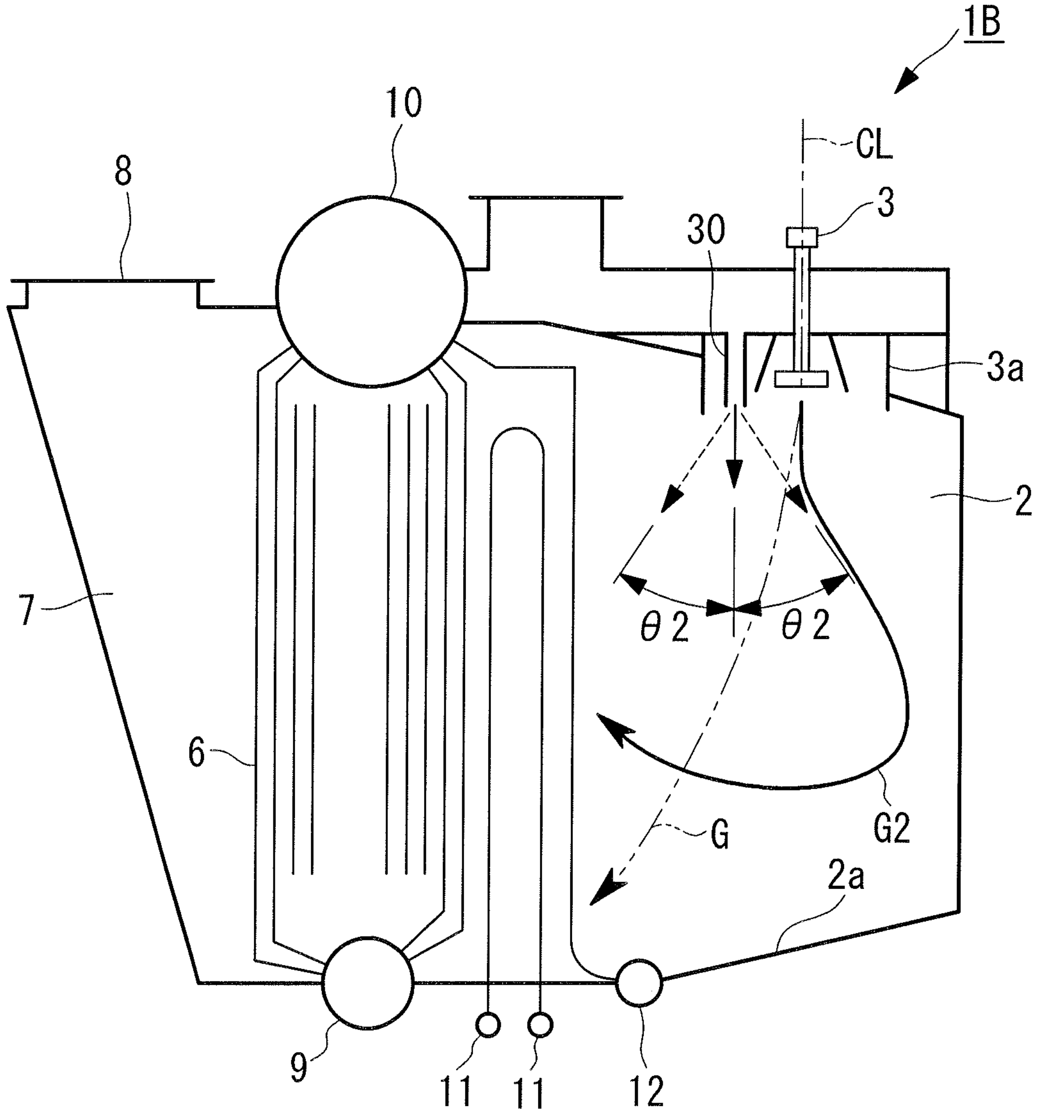


FIG. 4A

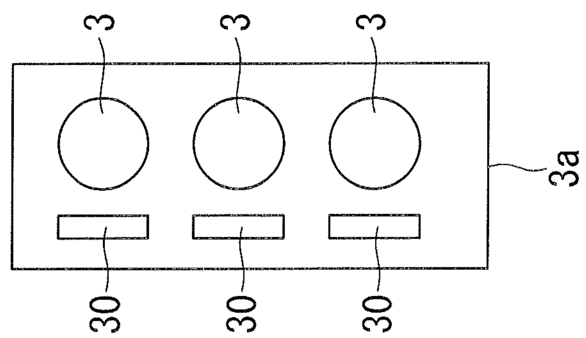


FIG. 4B

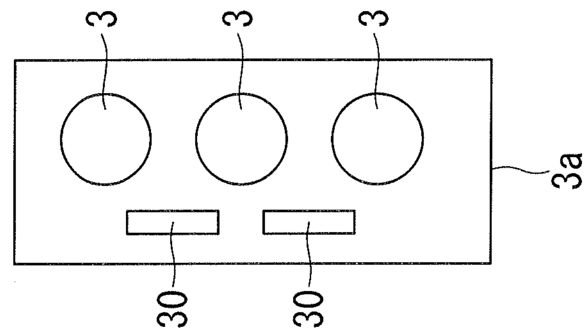


FIG. 4C

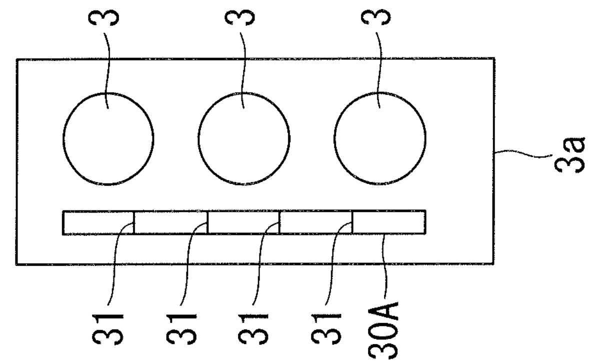
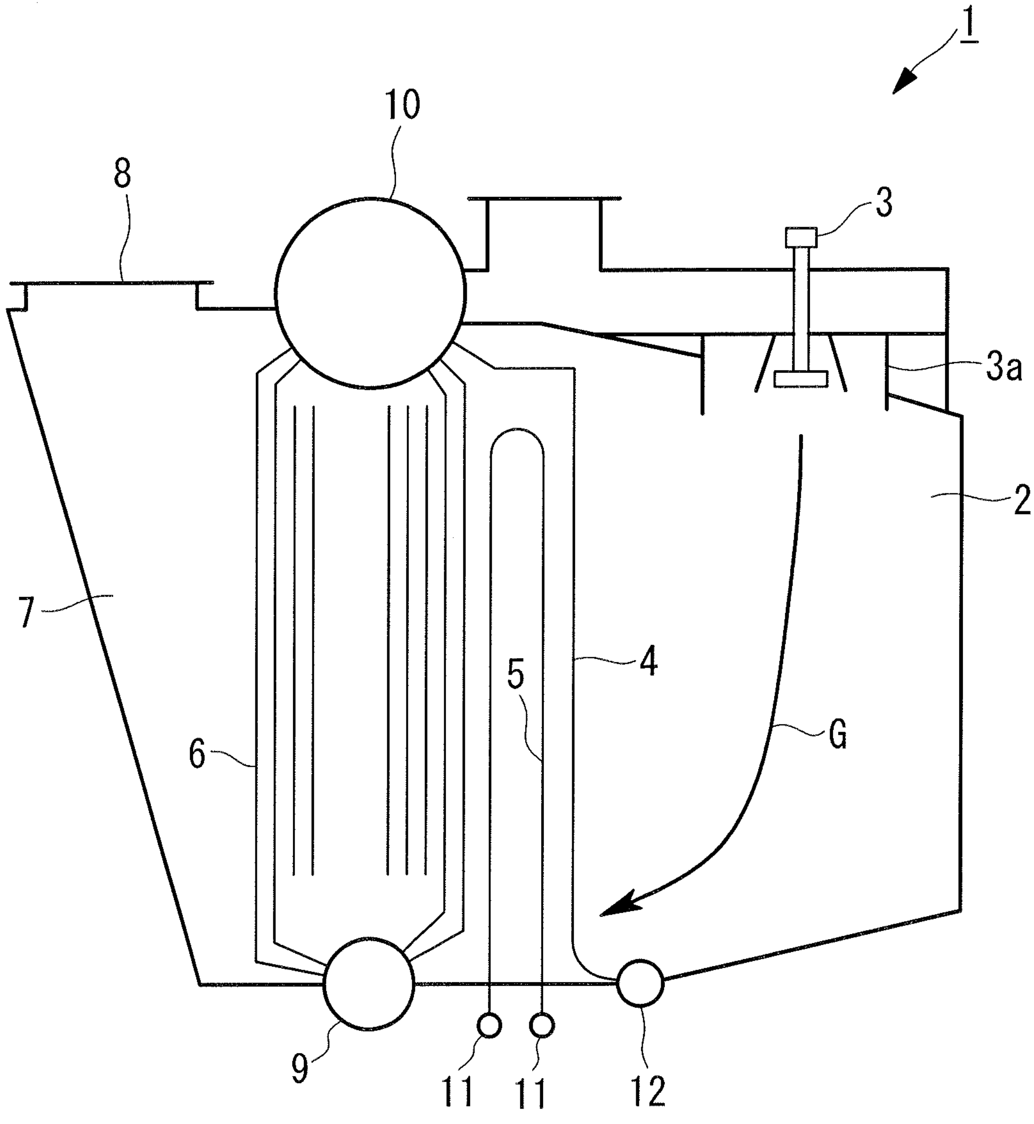


FIG. 5



INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2008/062570

A. CLASSIFICATION OF SUBJECT MATTER
F23C99/00(2006.01)i, *F22B21/04*(2006.01)i, *F22B31/00*(2006.01)i, *F22B37/00*(2006.01)i, *F23L9/02*(2006.01)i, *F23L9/06*(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)
F23C99/00, F22B21/04, F22B31/00, F22B37/00, F23L9/02, F23L9/06

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

Jitsuyo Shinan Koho	1922-1996	Jitsuyo Shinan Toroku Koho	1996-2008
Kokai Jitsuyo Shinan Koho	1971-2008	Toroku Jitsuyo Shinan Koho	1994-2008

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 Y	JP 2002-195504 A (Mitsubishi Heavy Industries, Ltd.), 10 July, 2002 (10.07.02), Column 3, line 44 to column 5, line 34; Figs. 1 to 2 (Family: none)	2-3 1
Y	JP 53-090023 A (Ishikawajima-Harima Heavy Industries Co., Ltd.), 08 August, 1978 (08.08.78), Page 2, lower left column, line 1 to page 3, upper left column, line 11; Fig. 3 (Family: none)	1

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

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Date of the actual completion of the international search	Date of mailing of the international search report
01 September, 2008 (01.09.08)	09 September, 2008 (09.09.08)

Name and mailing address of the ISA/	Authorized officer
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INTERNATIONAL SEARCH REPORT

International application No.
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C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

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REFERENCES CITED IN THE DESCRIPTION

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