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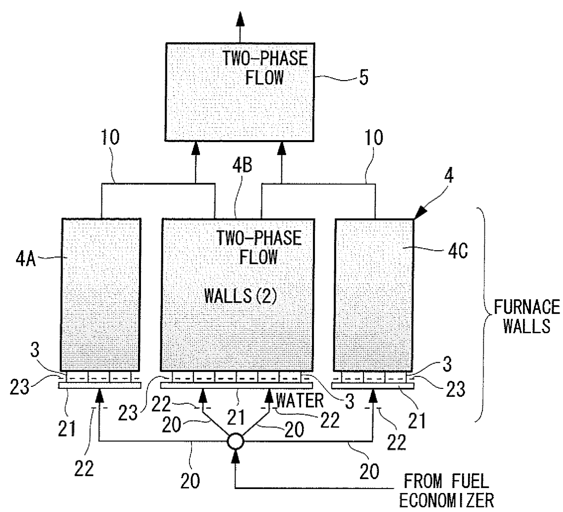
(54) **BOILER STRUCTURE**

(57) A boiler structure that allows for an appropriate flow-rate distribution of an internal fluid to multiple divided furnace wall surfaces (water-wall) without excessive pressure loss so as to reduce the pressure loss (friction loss) occurring between furnace inlet headers and outlet headers is provided. In a boiler structure having a furnace water-wall (4) formed of multiple boiler evaporation tubes (3) disposed on a wall surface of a furnace and configured to generate steam by heating water inside the furnace when the water pressure-fed to the boiler evaporation tubes (3) flows inside the tubes, the boiler structure includes orifices (22), for an internal fluid, provided in inlet connection tubes (20) that guide the water to inlet headers (21) of furnace walls obtained by dividing the furnace water-wall (4) into multiple parts, and orifices (23) provided in nozzle stubs that guide the water from the inlet headers (21) to the boiler evaporation tubes (3).

FIG. 1



EP 2 357 407 A1

Description

{Technical Field}

[0001] The present invention relates to boiler structures that optimize the flow-rate distribution in boiler evaporation tubes (furnace water-walls).

{Background Art}

[0002] In furnaces of supercritical variable-pressure once-through boilers in the related art, particularly, vertical-tube furnaces having furnace water-walls (furnace walls) formed of multiple boiler evaporation tubes arrayed in the vertical direction, it is important to adjust the flow rate of an internal fluid flowing in the furnace walls. This flow-rate adjustment not only requires adjusting the flow rate for the individual boiler evaporation tubes in accordance with the thermal load distribution within the furnace walls, but also requires adjusting differences in loss of pressure (also referred to as "pressure loss" hereinafter) occurring due to differences in system channels among the individual furnace walls (front wall, rear wall, and left and right walls).

[0003] Specifically, with regard to the flow-rate adjustment of the internal fluid flowing in the furnace walls (front wall, rear wall, and left and right walls), appropriate flow-rate distribution from a partial load to a rated load is necessary. Therefore, in the boiler structure of the related art, orifices are provided in nozzle stubs at the furnace inlets for the purpose of adjusting the flow rate of the internal fluid described above.

[0004] In a boiler device of the related art, a technology of performing distributive adjustment of the feedwater flow rate between the furnace walls or between divided blocks is known. In this technology of the related art, flow-rate control valves are provided at the inlets of the furnace walls, and the fluid temperature detected at the outlets of the furnace walls is input to a control device. Therefore, the control device automatically controls the feedwater flow rate and performs distributive adjustment by controlling the degree of opening of the flow-rate control valves so that the input fluid temperature at the outlets becomes equal to a target value (for example, see Patent Citations 1 and 2).

{Citation List}

{Patent Literature}

[0005]

{PTL 1} Japanese Unexamined Patent Application, Publication No. Sho 59-86802
{PTL 2} Japanese Unexamined Patent Application, Publication No. Sho 59-84001

{Summary of Invention}

{Technical Problem}

[0006] As described above, with regard to the flow-rate adjustment of the internal fluid flowing in the furnace water-wall, orifices are disposed in nozzle stubs of inlet headers provided for the individual furnace walls, and these orifices are used for performing flow-rate adjustment that accords with the thermal load distribution within the furnace walls, for the individual boiler evaporation tubes. However, regarding the internal fluid flowing within the water-wall surfaces of the furnace water-wall, it is effective to reduce friction loss from the inlet headers to the outlet headers for the individual furnace walls so as to ensure flow stability therein.
Therefore, with the flow-rate adjustment by the orifices disposed at the nozzle stubs, the pressure loss occurring between the inlet headers and the outlet headers of the individual furnace walls can be prevented from becoming excessive so long as pressure-loss adjustment intended only for adjusting the flow-rate distribution for the individual boiler evaporation tubes within the furnace walls is possible, or in other words, so long as the orifice diameter can be set solely on the basis of flow-rate adjustment for the individual boiler evaporation tubes.

[0007] However, the orifice diameter in the related art is set so as to correct pressure-loss differences among the multiple divided furnace walls. Therefore, with regard to the pressure loss from the furnace inlet headers to the outlet headers, since the orifice diameter tends to become smaller when adjusting the pressure-loss differences, the increase in pressure loss due to the orifices becomes greater. Specifically, since the orifices of the related art also adjust pressure-loss differences in system channels that differ among the multiple furnace walls in addition to performing the flow-rate adjustment that accords with the thermal load distribution within the furnace water-wall, for the individual boiler evaporation tubes, there is room for improvement in that the overall pressure loss in the furnace water-wall, including the pressure loss in the orifices, becomes higher than in an ideal case.
The present invention has been made in view of these circumstances, and an object thereof is to provide a boiler structure that allows for appropriate flow-rate distribution of an internal fluid to multiple divided furnace wall surfaces (furnace walls) without excessive pressure loss so as to reduce the pressure loss (friction loss) occurring between furnace inlet headers and outlet headers.

{Solution to Problem}

[0008] In order to solve the aforementioned problems, the present invention provides the following solutions.
In a boiler structure according to an aspect of the present invention having a furnace water-wall formed of multiple boiler evaporation tubes disposed on a wall surface of a

furnace and configured to generate steam by heating water inside the furnace when the water pressure-fed to the boiler evaporation tubes flows inside the tubes, the boiler structure includes first pressure-loss adjusting sections, for an internal fluid, provided in distribution tubes that guide the water to inlet headers of furnace walls obtained by dividing the furnace water-wall into multiple parts, and second pressure-loss adjusting sections provided in nozzle stubs that guide the water from the inlet headers to the boiler evaporation tubes.

[0009] With such a boiler structure, because the first pressure-loss adjusting sections, for the internal fluid, provided in the distribution tubes that guide the water to the inlet headers of the furnace walls obtained by dividing the furnace water-wall into multiple parts and the second pressure-loss adjusting sections provided in the nozzle stubs that guide the water from the inlet headers to the boiler evaporation tubes are provided, the first pressure-loss adjusting sections and the second pressure-loss adjusting sections can share roles such that the first pressure-loss adjusting sections are configured to correct pressure-loss differences among the multiple divided water-walls and the second pressure-loss adjusting sections are configured to perform flow-rate adjustment that accords with the thermal load distribution within the furnace water-wall, for the individual boiler evaporation tubes.

The first pressure-loss adjusting sections and the second pressure-loss adjusting sections may be configured to perform desired pressure-loss adjustment by dividing each of them into multiple stages depending on conditions such as the diameter of channels where they are to be installed.

[0010] In the above aspect, it is desirable that the first pressure adjusting sections be configured by using one of or combining a plurality of fixed orifices fitted in the distribution tubes, thick-walled short tubes having the same outer diameter as the distribution tubes and fitted therein, and individual adjustment of a pressure loss occurring in the distribution tubes.

In this case, the fixed orifices fitted in the outlet connection tubes can adjust the pressure loss by varying the orifice diameter thereof.

The thick-walled short tubes having the same outer diameter as the outlet connection tubes and fitted therein are each formed of a tubular member whose inner diameter is reduced by increasing the wall thickness thereof and can adjust the pressure loss by varying the inner diameter and the length thereof.

With the individual adjustment of the pressure loss occurring in the outlet connection tubes, it is possible to adjust the pressure loss by varying at least one of the inner diameter of the tubular member used for forming each outlet connection tube, the number thereof, and the channel length thereof.

{Advantageous Effects of Invention}

[0011] According to the present invention described above, since the first pressure-loss adjusting sections and the second pressure-loss adjusting sections provided on the upstream side of the furnace water-wall have different functions with respect to the flow-rate distribution to the furnace water-wall, an appropriate distribution can be achieved without excessive pressure loss.

In consequence, a pressure loss (friction loss) that occurs due to the flow of an internal fluid can be reduced between the furnace inlet headers and outlet headers through which the internal fluid flows. Therefore, flow stability and natural circulation of the internal fluid within the furnace water-wall are enhanced, thereby achieving a significant advantage of providing a highly-reliable boiler structure.

{Brief Description of Drawings}

[0012]

{FIG. 1} Fig. 1 is a systematic view showing a first embodiment, as an embodiment of a boiler structure according to the present invention.

{FIG. 2} Fig. 2 is a perspective view showing an overview of the boiler structure.

{FIG. 3} Fig. 3 is a systematic view showing a first modification of Fig. 1.

{FIG. 4} Fig. 4 is a systematic view showing a second modification of Fig. 1.

{FIG. 5} Fig. 5 is a systematic view showing a second embodiment, as an embodiment of a boiler structure according to the present invention.

{FIG. 6} Fig. 6 is a systematic view showing a first modification of Fig. 2.

{FIG. 7} Fig. 7 is a systematic view showing a second modification of Fig. 2.

{Description of Embodiments}

[0013] Embodiments of a boiler structure according to the present invention will be described below with reference to the drawings.

{First Embodiment}

[0014] In an embodiment shown in Figs. 1 and 2, a boiler 1 is a supercritical variable-pressure once-through boiler having a furnace water-wall 4 formed of multiple boiler evaporation tubes 3 disposed on a wall surface of a furnace 2 and configured to generate steam by heating water inside the furnace 2 when the water pressure-fed to the boiler evaporation tubes 3 flows inside the tubes. The boiler 1 in the drawings is rectangular in horizontal cross section of the furnace 2, and the furnace water-wall 4 is formed by being divided into four furnace walls, i.e., front, rear, left, and right faces; for example, as shown in Fig. 1, the furnace walls are connected to a roof water-wall 5 via outlet connection tubes 10.

In Fig. 1, the furnace water-wall 4 is divided into four furnace walls including a left wall 4A, a front wall 4B, and a right wall 4C.

[0015] Water used for generating steam is fed to the aforementioned furnace water-wall 4 from a fuel economizer. The water fed from the fuel economizer is distributed, via inlet connection tubes 20, to inlet headers 21 provided respectively for the four divided furnace walls. Specifically, the inlet connection tubes 20 function as distribution tubes for feeding water by distributing and guiding the water introduced from the fuel economizer to the inlet headers 21 provided on the upstream side of the four divided furnace walls, i.e., the left wall 4A, the front wall 4B, a rear wall 4C, and the right wall 4C.

The multiple boiler evaporation tubes 3 that extend in the vertical direction and form the furnace water-wall 4 are connected to nozzle stubs of the inlet headers 21.

[0016] In order to adjust the flow rate of an internal fluid distributively flowing in the aforementioned furnace walls, or in other words, in order to adjust the flow rate of water distributively fed to the furnace water-wall 4, the inlet connection tubes 20 are each provided with an orifice 22 serving as a first pressure-loss adjusting section for the internal fluid. The orifices 22 used here are fixed orifices with desired orifice diameters that differ among the individual inlet connection tubes 20 depending on flow-rate adjustment. The orifice diameters in this case are set so as to correct pressure-loss differences in system channels that differ among the furnace walls.

In an inlet section of each of the aforementioned boiler evaporation tubes 3, the nozzle stub that guides water from the corresponding inlet header 21 to the boiler evaporation tube 3 is provided with an orifice 23 serving as a second pressure-loss adjusting section. In order to perform flow-rate adjustment that accords with the thermal load distribution within the furnace water-wall 4, the orifices 23 used here are fixed orifices with desired orifice diameters that differ among the individual boiler evaporation tubes 3.

[0017] In the boiler 1 with this configuration, the two-stage orifices 22 and 23 provided at the inlet side of the furnace 2 perform flow-rate adjustment (distribution) of the internal fluid for each feedwater system by adjusting a pressure loss in the internal fluid.

Specifically, the two-stage orifices 22 and 23 are provided in a role-sharing manner such that they perform different flow-rate adjustment, that is, the orifices 22 provided in the inlet connection tubes 20 that guide water to the inlet headers 21 of the furnace walls obtained by dividing the furnace water-wall 4 into multiple parts correct pressure-loss differences among the multiple divided water-walls, whereas the orifices 23 provided in the nozzle stubs that guide water from the inlet headers 21 to the respective boiler evaporation tubes 3 perform flow-rate adjustment that accords with the thermal load distribution within the furnace water-wall 4, for the individual boiler evaporation tubes 3.

[0018] In other words, the pressure-loss adjusting sections that are disposed at the inlet (upstream) side of the furnace and that adjust a pressure loss in the internal fluid are divided into the orifices 22 disposed in the split inlet connection tubes 20 at the upstream side of the inlet headers 21 and the orifices 23 disposed in the nozzle stubs at the furnace water-wall 4 side relative to the inlet headers 21, thereby reducing friction loss within the furnace water-wall (the inlet headers 21 at the furnace inlet - the furnace water-wall (front wall, rear wall, and left and right walls) - headers at the furnace outlet) and consequently enhancing flow stability and natural circulation within the furnace water-wall.

The orifices 22 and 23 of the above embodiment may each be divided into multiple stages depending on conditions such as the diameter of channels where they are to be installed; in other words, multistage orifices may be arranged in series so as to perform desired pressure-loss adjustment.

[0019] Next, a first modification of the above embodiment will be described with reference to Fig. 3. Components similar to those in the above embodiment are given the same reference numerals, and detailed descriptions thereof will be omitted.

In this modification, in place of the orifices 22 serving as the first pressure-loss adjusting sections, thick-walled short tubes 24 with the same outer diameter as the inlet connection tubes 20 are fitted therein. The thick-walled short tubes 24 optimally adjust the flow-rate distribution for the furnace walls on the basis of a pressure loss that occurs when the internal fluid in the water state passes through the thick-walled short tubes 24. The thick-walled short tubes 24 in this case have the same outer diameter as the inlet connection tubes 20, and tubular members whose inner diameter is reduced by increasing the wall thickness thereof are used. Specifically, by varying the inner diameter and the length of the thick-walled short tubes 24, the pressure loss can be adjusted.

[0020] Next, a second modification of the above embodiment will be described with reference to Fig. 4. Components similar to those in the above embodiment are given the same reference numerals, and detailed descriptions thereof will be omitted.

In place of the orifices 22 serving as the first pressure-loss adjusting sections, this modification employs individual adjustment of the pressure loss that occurs when the internal fluid flows through the inlet connection tubes 20. Specifically, regarding the inlet connection tubes 20 shown with thick lines in the drawing, the pressure loss is adjusted by varying at least one of the inner diameter of the tubular members used for forming the inlet connection tubes 20, the number thereof, and the channel length thereof.

[0021] With regard to the fixed orifices 22 fitted in the inlet connection tubes 20, the thick-walled short tubes 24 having the same outer diameter as the inlet connection tubes 20 and fitted therein, and the individual adjustment of the pressure loss occurring in the inlet connection tubes 20, the aforementioned first pressure adjusting sections may be configured by using one of the above or combining a plurality of the above. Employing an optimal combination in accordance with the conditions can allow for, for example, finer adjustment of the pressure loss and an increased adjustment range.

{Second Embodiment}

[0022] In embodiments shown in Figs. 5 to 7, furnace water-walls 6A, 6B, and 6C obtained by dividing a rear wall 6 into three parts are further provided in addition to the four divided walls, i.e., the left wall 4A, the front wall 4B, the rear wall 4C, and the right wall 4C.

Water fed from the fuel economizer to the rear wall 6 is heated, as in the furnace water-wall 4, so as to become a two-phase flow or vaporized internal fluid. This internal fluid is distributed to a channel line in which the internal fluid travels through an outlet connection tube 30, which connects the rear wall 6 and the downstream side of the roof water-wall 5, via an intermediate sub sidewall tube 7 so as to merge with steam generated by the furnace water-wall 4 and to a channel line in which the internal fluid travels through an outlet connection tube 31, which connects the additional water-wall 6 and the downstream side of the roof water-wall 5, via an intermediate rear-wall suspended tube 8 so as to merge with the steam generated by the furnace water-wall 4.

[0023] In such a boiler structure, each of the inlet connection tubes 20 is similarly provided with a first pressure-loss section and a second pressure-loss section for the internal fluid so that pressure-loss adjustment is performed.

As the first pressure-loss adjusting sections provided in the inlet connection tubes 20, an embodiment shown in Fig. 5 employs the individual adjustment of the pressure loss. Specifically, the pressure loss is adjusted by varying at least one of the inner diameter of the tubular members used for forming the inlet connection tubes 20 through which water flows, the number thereof, and the channel length thereof.

[0024] In a first modification of the present embodiment shown in Fig. 6, the thick-walled short tubes 24 fitted in midsections of the inlet connection tubes 20, through which water flows, are employed as the first pressure-loss adjusting sections provided in the inlet connection tubes 20. Specifically, the thick-walled short tubes 24 whose inner diameter is reduced by increasing the wall thickness thereof and having the same outer diameter as the inlet connection tubes 20 are each fitted in the midsection of a tubular member used for forming each inlet connection tube 20, and the pressure loss is adjusted by appropriately varying the inner diameter and the length thereof.

In a second modification of the present embodiment shown in Fig. 7, the orifices 22 fitted in midsections of the inlet connection tubes 20, in which the internal fluid is water, are employed as the first pressure-loss adjusting sections provided in the inlet connection tubes 20. Specifically, the orifices 22 are each fitted in the midsection of a tubular member used for forming each inlet connection tube 20, and the pressure loss is adjusted by appropriately varying the orifice diameter thereof.

The first pressure adjusting sections shown in Figs. 5 to 7 may be configured by using any one of: the individual adjustment of the pressure loss in the inlet connection tubes 20 and the like, the thick-walled short tubes 24 fitted therein, and the orifices 22 fitted therein, or by appropriately combining a plurality of the above.

[0025] With the boiler structure described above, the first pressure-loss adjusting sections, such as the orifices 22, and the second pressure-loss adjusting sections, such as the orifices 23, provided on the upstream side of the furnace water-wall 4 have different functions with respect to the flow-rate distribution to the furnace water-wall 4 so as to allow for an appropriate distribution without excessive pressure loss.

In consequence, a pressure loss (friction loss) that occurs due to the flow of an internal fluid can be reduced between the inlet headers 21 and outlet headers of the furnace 2 through which the internal fluid flows. Therefore, flow stability and natural circulation of the internal fluid within the furnace water-wall 4 are enhanced, whereby a highly-reliable boiler structure can be provided.

The present invention is not limited to the above embodiments, and appropriate modifications are permissible so long as they do not depart from the spirit of the invention.

{Reference Signs List}

[0026]

1	boiler
2	furnace
3	boiler evaporation tube
4	furnace water-wall
5	roof water-wall
6	rear wall (furnace water-wall)
10	outlet connection tube
20	inlet connection tube (distribution tube)
21	inlet header
22, 23	orifice
24	thick-walled short tube

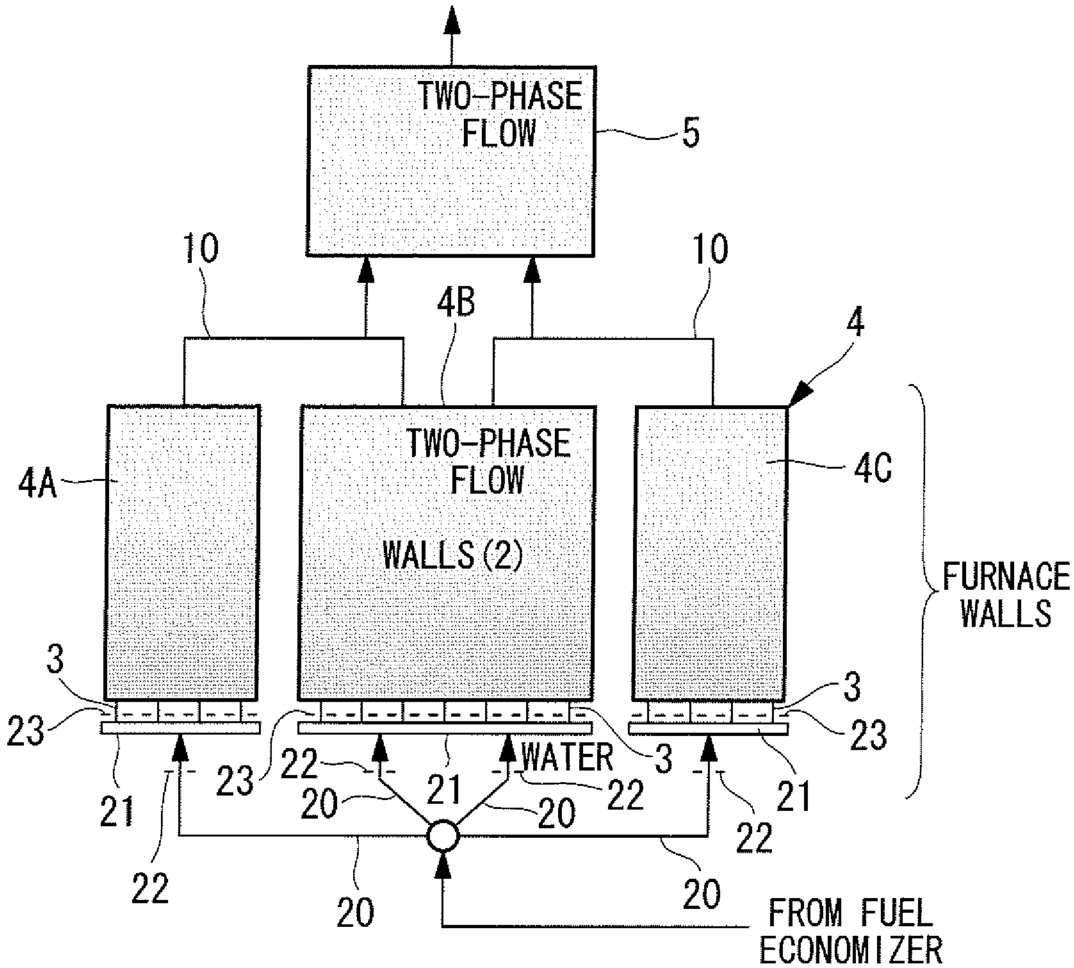
Claims

1. A boiler structure having a furnace water-wall formed of multiple boiler evaporation tubes disposed on a wall surface of a furnace and configured to generate steam by heating water inside the furnace when the water pressure-fed to the boiler evaporation tubes flows inside the tubes, the boiler structure comprising:

   first pressure-loss adjusting sections, for an internal fluid, provided in distribution tubes that guide the water to inlet headers of furnace walls obtained by dividing the furnace water-wall into multiple parts, and second pressure-loss adjusting sections provided in nozzle stubs that guide the water from the inlet headers to the boiler evaporation tubes.

2. The boiler structure according to Claim 1, wherein the first pressure adjusting sections are configured by using one of or combining a plurality of fixed orifices fitted in the distribution tubes, thick-walled short tubes having the same outer diameter as the distribution tubes and fitted therein, and individual adjustment of a pressure loss occurring in the distribution tubes.

FIG. 1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4C
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23
3
23
22
WATER
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20
FROM FUEL ECONOMIZER

FIG. 2

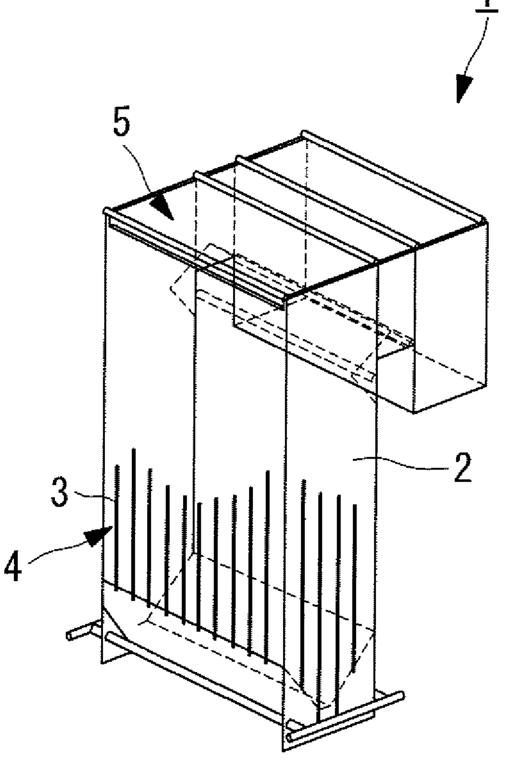
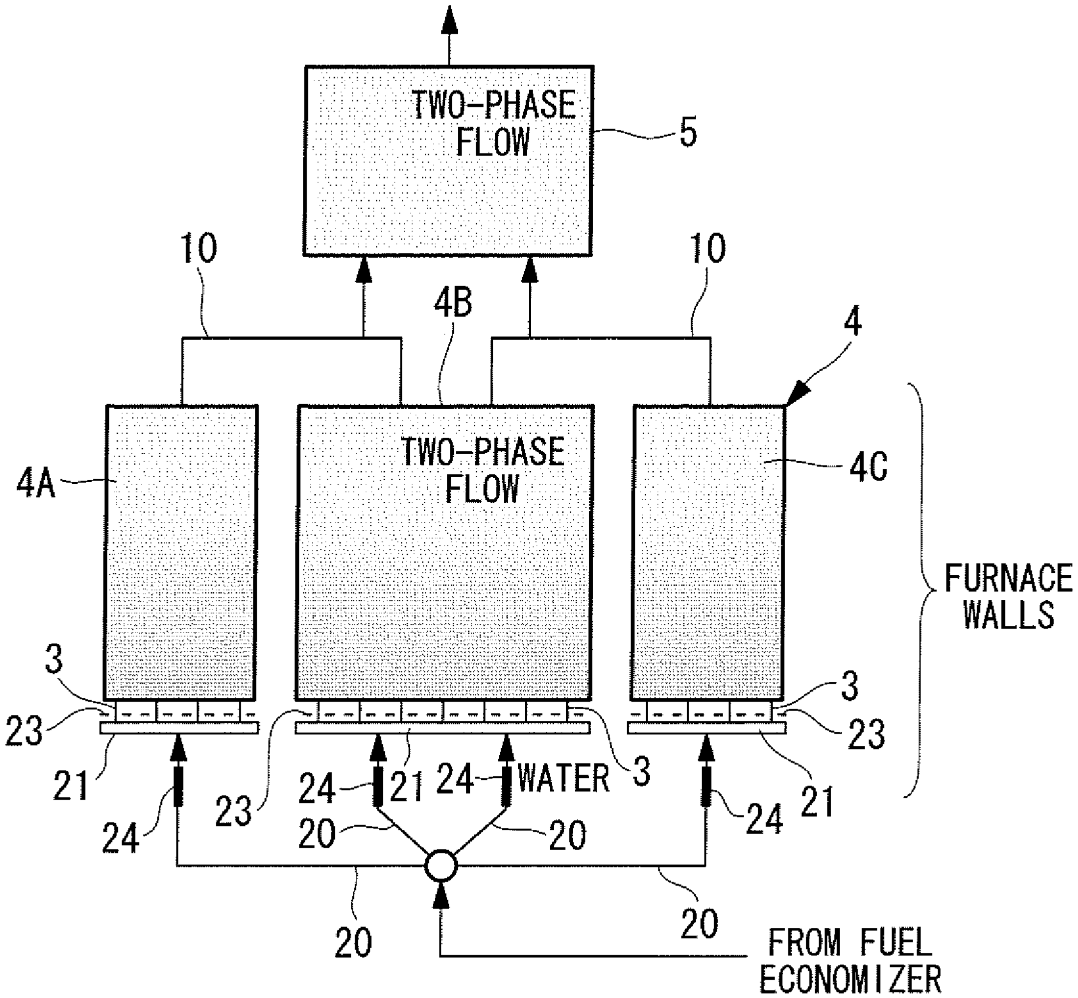


FIG. 3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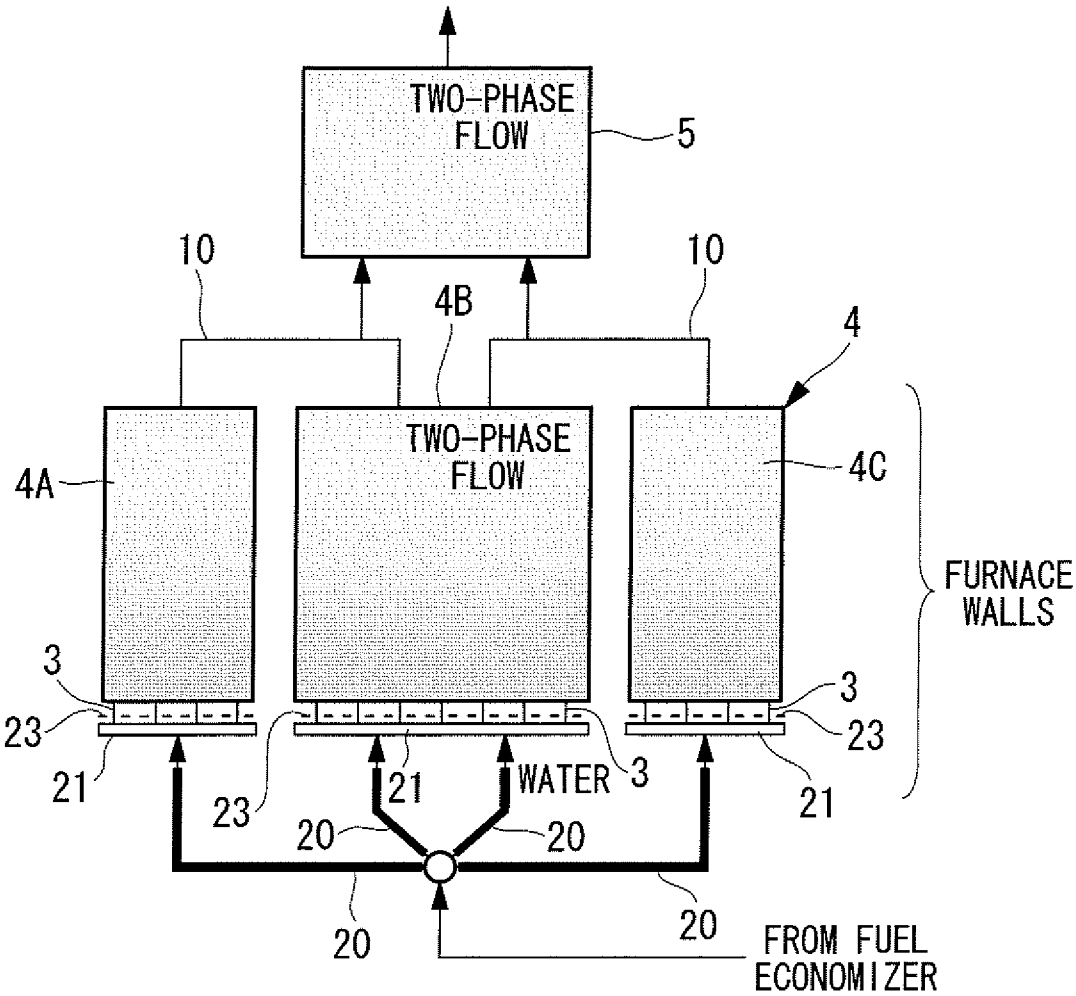
FROM FUEL ECONOMIZER

FIG. 4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TWO-PHASE FLOW
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FROM FUEL ECONOMIZER

FIG. 5

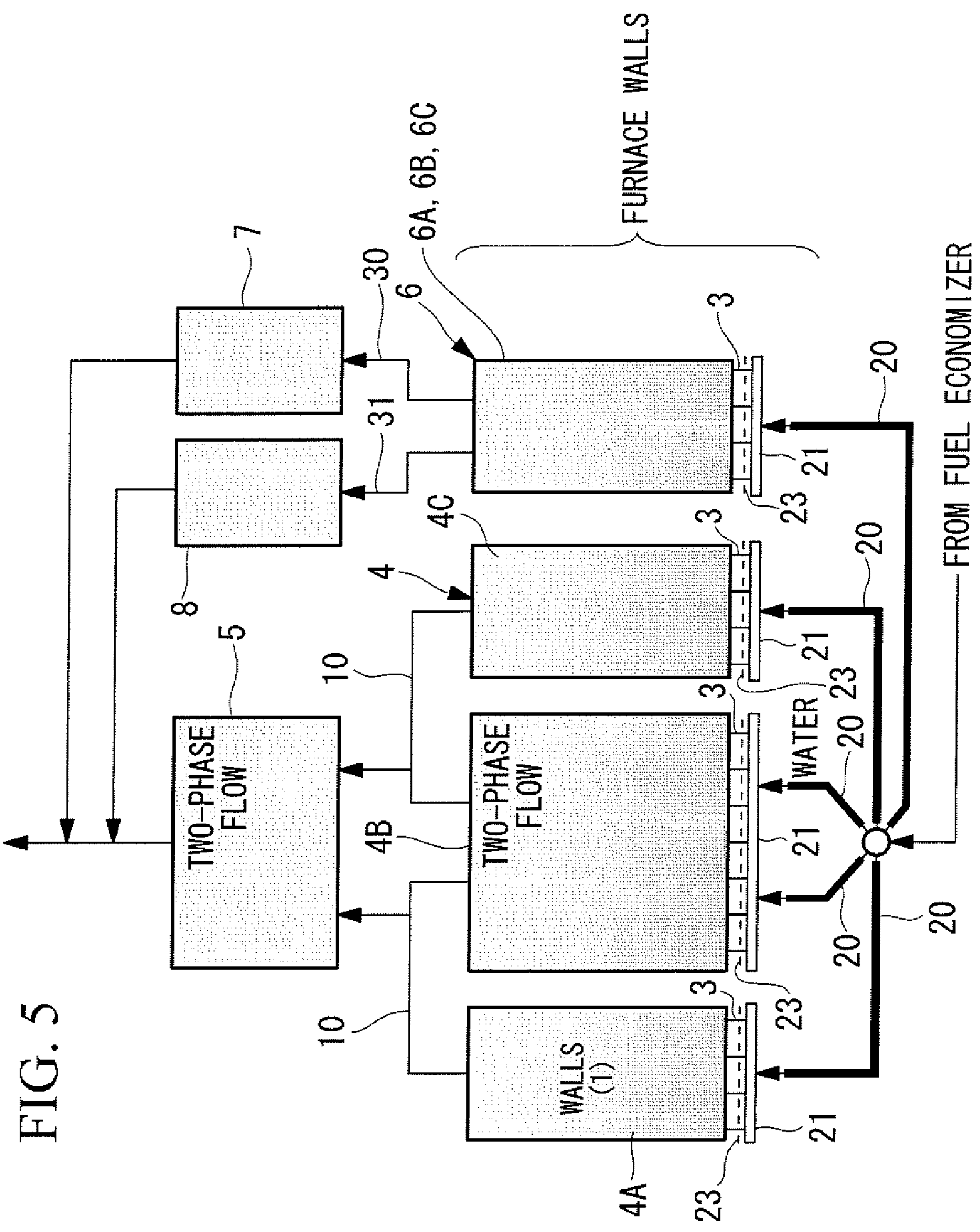
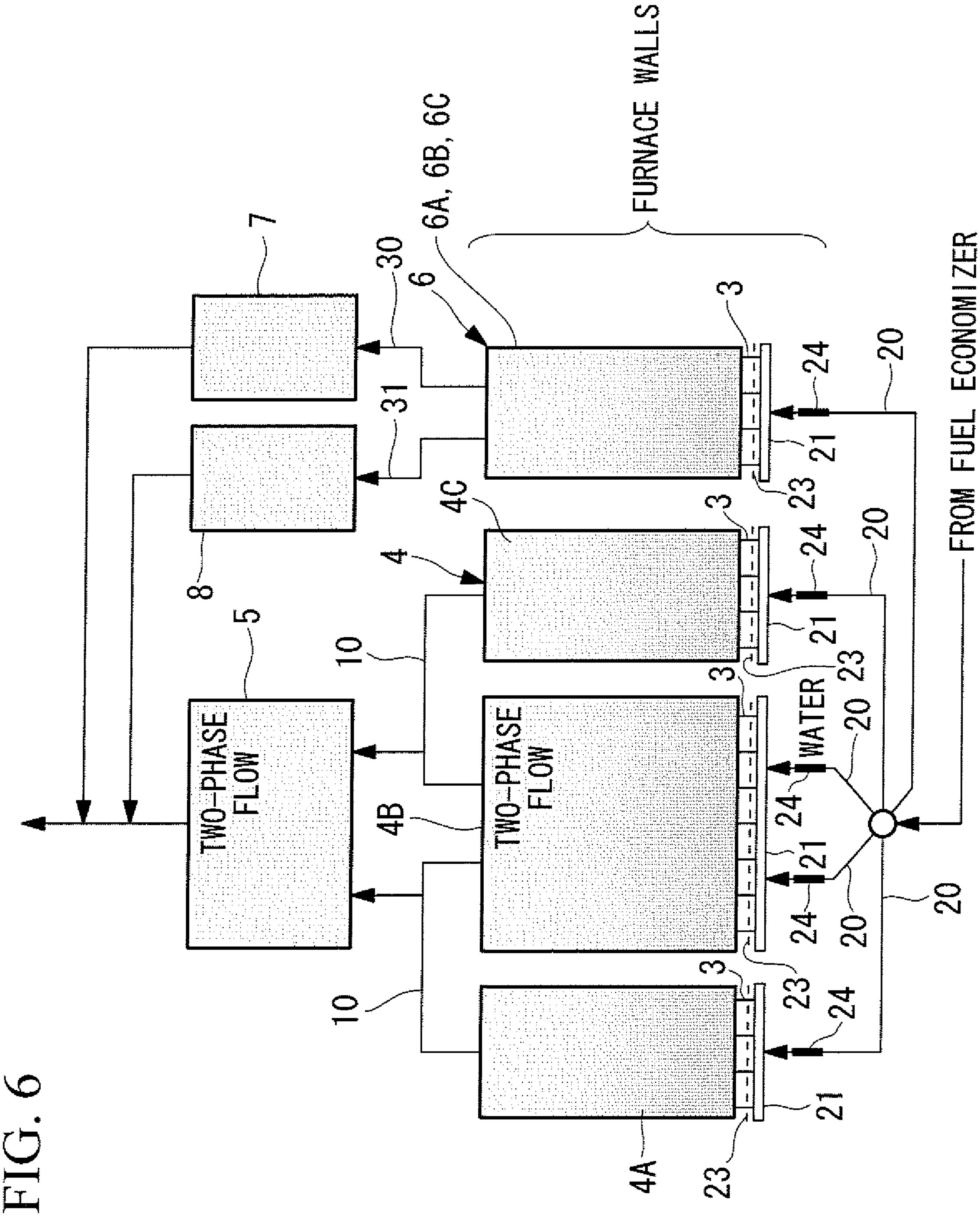

FURNACE WALLS
6A, 6B, 6C
7
30
6
31
8
5
TWO-PHASE FLOW
4C
4
10
4B
TWO-PHASE FLOW
WATER
WALLS (1)
4A
3
20
21
23
FROM FUEL ECONOMIZER

FIG. 6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4A
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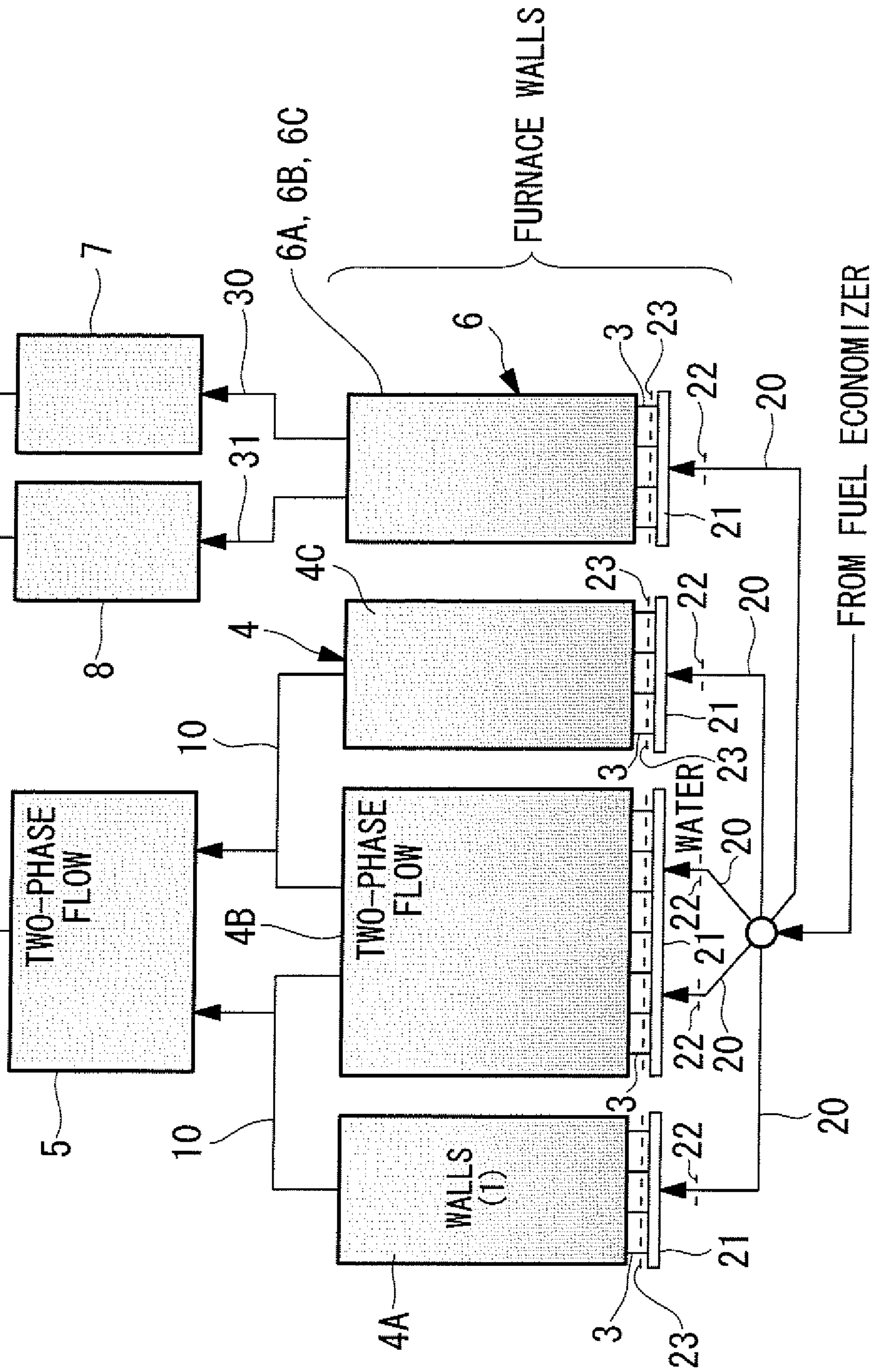
23
24
20
FROM FUEL ECONOMIZER

FIG. 7


FURNACE WALLS
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TWO-PHASE FLOW
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FROM FUEL ECONOMIZER
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31
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21
22
23

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2009/062120

A. CLASSIFICATION OF SUBJECT MATTER
F22B37/22(2006.01)i, F22B37/70(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)
F22B37/22, F22B37/70

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

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

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	JP 59-129306 A (Mitsubishi Heavy Industries, Ltd.), 25 July, 1984 (25.07.84), Figs. 1, 2, 4 (Family: none)	1,2
A	JP 59-86802 A (Babcock-Hitachi Kabushiki Kaisha), 19 May, 1984 (19.05.84), Full text; all drawings (Family: none)	1,2

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

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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
21 August, 2009 (21.08.09)	01 September, 2009 (01.09.09)

Name and mailing address of the ISA/	Authorized officer
Japanese Patent Office	
Facsimile No.	Telephone No.

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

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Patent documents cited in the description

- JP SHO5986802 B **[0005]**
- JP SHO5984001 B **[0005]**