(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) **EP 1 500 875 A1**

(12) **EUROPEAN PATENT APPLICATION**
published in accordance with Art. 158(3) EPC

(43) Date of publication:
26.01.2005 Bulletin 2005/04

(21) Application number: **03710255.5**

(22) Date of filing: **06.03.2003**

(51) Int Cl.[7]: **F23G 5/50**, F23G 5/00, F23G 5/44, F23G 5/30

(86) International application number:
PCT/JP2003/002623

(87) International publication number:
WO 2003/093728 (13.11.2003 Gazette 2003/46)

(84) Designated Contracting States:
AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HU IE IT LI LU MC NL PT RO SE SI SK TR
Designated Extension States:
AL LT LV MK

(30) Priority: **02.05.2002 JP 2002130526**
15.08.2002 JP 2002237022
15.08.2002 JP 2002237023
15.08.2002 JP 2002237024

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DE FR GB

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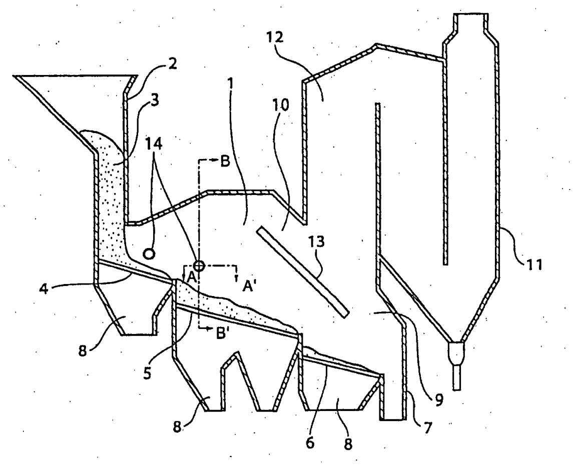
(54) **METHOD OF OPERATING WASTE INCINERATOR AND WASTE INCINERATOR**

(57) The present invention provides a method for operating a waste incinerator: the method comprises a step of blowing high-temperature gas having a temperature T[°C] that is 200°C or higher and satisfies $\exp(7.78 - 0.18C) \leqq T \leqq \exp(7.45 - 0.11C)$ into a combustion chamber of the waste incinerator and the like. C is defined as oxygen concentration (vol.%) in the high-temperature gas. In accordance with the present invention, in the waste incinerator, hazardous substances such as NOx and CO are reduced sufficiently while combustion is done at a low air excess ratio.

FIG. 3



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Description

TECHNICAL FIELD

[0001] The present invention relates to a method for operating a waste incinerator in order to incinerate waste such as general waste, industrial waste, and sewage sludge, andawasteincinerator, which is appropriate for carrying out the operating method.

BACKGROUND ART

[0002] As an incinerator for incinerating waste such as municipal refuse, a stoker incinerator or a fluidized bed waste incinerator is widely used. The typical example is shown in Fig.1. Waste 32 that is charged into a hopper 31 is fed to a drying stoker 33 through a chute. On the drying stoker 33, the waste 32 is dried by air sent from the bottom-part and by radiation heat in a furnace. And, at the same time, the waste is heated and ignited. The waste 32, which has been ignited and begun to burn, is fed onto a burning stoker 34, where the waste 32 is thermally decomposed by the combustion air that is sent from the bottom-part, resulting in being gasified, simultaneously with burning some parts of the waste. Furthermore, unburnt combustibles in the waste burn completely on an after- burning stoker 35. Ash that remains after the burning is taken out to the outside through a main ash chute 36.

[0003] Combustion is accomplished in a combustion chamber 37, and generated combustion gas is separated into two flue, these are, a main flue 39 and a bypass flue 40, by an intermediate ceiling 38, and then the generated combustion gas is discharged. The exhaust gas, which passes through the main flue 39, scarcely contains combustible gas. The exhaust gas contains oxygen to an extent of approximately 10% or more as much as the total amount of the exhaust gas. The exhaust gas, which passes through the bypass flue 40, contains the combustible gas, whose amount is approximately 8% as much as the total amount of the exhaust gas. The exhaust gas is mixed with each other in a secondary combustion chamber 41, and subjected to secondary combustion. As a result, the combustible gas burns completely. The exhaust gas from the secondary combustion chamber 41 is fed into to a waste heat boiler 43. After exchanging the heat the exhaust gas passes through a temperature-reducing tower, and passes through a bag filter or the like. Afterwards, the exhaust gas is discharged to the outside of the process.

[0004] In case that the waste is incinerated in such a stoker or a fluidized bed waste incinerator, it is difficult to keep the combustion state in the furnace constant. Because, the waste consists of many substances having different characteristics. Therefore, it becomes inevitable that there occurs non-uniform distribution of the temperature in the combustion chamber 37 and the concentration of combustion gas from the viewpoint of time and room.

[0005] As a method for solving the above problems, Unexamined Japanese Patent Publication No. 11-211044 has disclosed a method in which high-temperature gas generated by a regenerative burner is blown into the combustion chamber or the secondary combustion chamber of the incinerator.

[0006] Also, Unexamined Japanese Patent Publication No. 11-223323 has disclosed a method in which high-temperature gas generated by a regenerative burner is blown into the incinerator at a temperature of 800°C or higher.

[0007] All of these technologies aim at reducing CO, combustible gas containing much aromatic hydrocarbon, hazardous substances. and the like in the exhaust gas generated in the incinerator.

[0008] However, the method disclosed in Unexamined Japanese Patent Publication No. 11-211044 discloses that the concentration of oxygen in the high-temperature gas is 20% or higher. So, in case that such a high-temperature gas is blown into the incinerator, rapid combustion happens in the incinerator, and hence there occurs a possibility to form high-temperature zone in a limited part of the incinerator. For example, if the high-temperature zone is formed in the limited part, the generation amount of NOx, increases, which is a hazardous substance.

[0009] Furthermore, the technology shown in Unexamined Japanese Patent Publication No. 11-223323, discloses that, in addition to the above-described problem, the thermal decomposition/partial oxidation of waste is promoted because an oxygen-containing gas is blown into the combustion chamber at a temperature of 800°C or higher, and, it may be a case, that CO generates.

[0010] Thus, even if any of the above-described methods is applied to, it is difficult to sufficiently reduce NOx, CO, and hazardous substances, which include dioxin in the exhaust gas, when the waste is incinerated by an incinerator such as a stoker incinerator.

[0011] On the other hand, in the conventional waste incinerator, a ratio (air excess ratio) obtained by dividing the actual amount of air by the theoretical amount of air, which is required for the combustion of the waste, is approximately 1.7 to 2.0. Such a ratio becomes higher than the value of 1.05 to 1.2, whose air excess ratio is required for the ordinary combustion. The reason why the air excess ratio becomes high is that the waste contains a lot of non-combustibles and the waste is inhomogeneous, so that a lot of amount of the air is required for the combustion. However, the higher the air excess ratio increases, the more the amount of the exhaust gas increases, so that a large scale equipment for treating the exhaust gas becomes necessary, compared with the ordinary combustion furnace.

[0012] If the air excess ratio decreases, the amount of the exhaust gas decreases, which enables the equipment for treating the exhaust gas to be compact. Consequently, the whole-size of the waste incineration facility becomes small, resulting in reducing the equipment cost. Furthermore, the amount of chemicals required for treating the exhaust gas decreases, so that the operational cost reduces. And furthermore, the heat loss that occurs by the insufficient heat recovery reduces, so that the efficiency for recovering the heat improves in a waste heat recovery boiler. Such an improvement brings up to rise the efficiency of the power generation in a refuse power generation system.
[0013] As described above, a low combustion of the air excess ratio invites a great advantage. But, such a low combustion of the air excess ratio makes the combustion to be unstable. That is to say, in the conventional combustion technology, in case that the combustion is done at a low excess air ratio, the combustion becomes unstable. Thus, the generation amount of CO increases, and the flame temperature rises in a limited part, so that the amount of NOx is apt to increase rapidly, a large of amount of the soot generates. And the clinker generates. Such phenomena as the high temperature in the limited part may invite a possibility to shorten the life of the refractories in the furnace.

DISCLOSURE OF THE INVENTION

[0014] The object of the present invention provides a method for operating a waste incinerator, where high-temperature gas blows into a combustion chamber. More particularly, the invention provides a method for operating a waste incinerator that is capable of sufficiently reducing the hazardous substances such as NOx and Co, while the combustion at a low air excess ratio is done. And the present invention provides a waste incinerator that is appropriate for carrying out the above operating method.
[0015] The object is attained by the method for operating the waste incinerator, which is described in the item i) to iv) below.

i) A method for operating a waste incinerator comprising a step of blowing high-temperature gas into a combustion chamber of the waste incinerator, where a temperature T[°C] is 200°C or higher, and wherein the temperature T [°C] satisfies the following equation (1).

$$\exp(7.78 - 0.18C) \leqq T \leqq \exp(7.45 - 0.11C) \tag{1}$$

ii) A method for operating a waste incinerator comprising a step of blowing high-temperature gas into a combustion chamber of the waste incinerator, which contains oxygen and at least one selected from the group consisting of carbon dioxide and water vapor , where a temperature T [°C] is 200°C or higher, and wherein the temperature T [°C] satisfies the following equation (2).

$$\exp(8.05 - 0.23C) \leqq T \leqq \exp(7.40 - 0.09C) \tag{2}$$

iii) Amethod for operating a waste incinerator comprising a step of blowing high-temperature gas into a combustion chamber of the waste incinerator, wherein a temperature T[°C] is lower than 200°C, and wherein the temperature T[°C] satisfies the following equation (3)

$$\exp(7.78 - 0.18C) \leqq T \tag{3}$$

iv) A method for operating a waste incinerator comprising a step of blowing high-temperature gas into a combustion chamber of the waste incinerator, which contains oxygen and at least one selected from the group consisting of carbon dioxide and water vapor , wherein a temperature T [°C] is lower than 200°C, and wherein the temperature T [°C] satisfies the following equation (4).

$$\exp(8.05 - 0.23C) \leqq T \tag{4}$$

wherein, C in accordance with the equation (1)-(4) expresses oxygen concentration (vol.%) in the high-temperature gas.
[0016] Furthermore, a method for operating such a waste incinerator is realized by a stoker or a fluidized bed waste incinerator that has equipment for blowing exhaust gas into a furnace, while the exhaust gas is circulated. In addition, the stoker or the fluidized bed waste incinerator provides an apparatus for circulating the exhaust gas, which adjusts

the characteristics of the high-temperature gas by mixing air with the exhaust gas, and which controls the oxygen concentration and the temperature of the high-temperature gas blown into a range, wherein the range exists from a region for starting combustion to a main combustion region in the furnace.

BRIEF DESCRIPTION OF THE DRAWINGS

[0017]

Fig. 1 is a schematic view showing an example of conventional waste incinerators;
Fig.2 is a graph showing the relationship between the temperature of high-temperature gas and the oxygen concentration of the high-temperature gas, which is blown into a furnace;
Fig.3 is a schematic view showing an example of waste incinerators in accordance with the present invention;
Fig.4A-4C are partially sectional views of Fig.3;
Fig.5 is a block diagram showing an example of exhaust gas circulation system in a waste incinerator in accordance with the present invention;
Fig. 6 is a block diagram showing another example of exhaust gas circulation system in a waste incinerator in accordance with the present invention;
Fig.7 is a graph showing the relationship between the temperature of high-temperature gas and the oxygen concentration of the high-temperature gas, which is blown into a furnace;
Fig.8 is a graph showing the relationship between temperature of high-temperature gas and oxygen concentration of the high-temperature gas, which is blown into a furnace; and
Fig.9 is a graph showing the relationship between temperature of high-temperature gas and oxygen concentration of the high-temperature gas, which is blown into a furnace.

EMBODIMENTS OF THE INVENTION

<u>Embodiment 1</u>

[0018] The inventors investigated, in a waste incinerator, the relationship between the CO and NOx generated in a combustion chamber, and the oxygen concentration and temperature of high-temperature gas blown into the combustion chamber. As a result, it was found that CO and NOx in the exhaust gas reduce at the same time, in case that the oxygen concentration in the high-temperature gas and the temperature of the high-temperature gas are controlled so as to be within a region bounded by line A, line B, and line C as shown in Fig.2.

[0019] In case that the temperature of the high-temperature gas at the time when the high-temperature gas is blown into the furnace is defined as T[°C], and in case that the oxygen concentration in the high-temperature gas is defined as C[vol.%], line A is expressed as $T = \exp(7.78 - 0.18C)$, line B as $T = \exp(7.45 - 0.11C)$, and line C as $T = 200$.

[0020] Blowing the high-temperature gas into the combustion chamber makes it possible for the waste to be heated by heat radiation from the high-temperature gas and by the sensible heat, and makes it possible to facilitate the thermal decomposition of the waste. Here, the high-temperature gas has the oxygen concentration and the temperatures in the region bounded by the line A, the line B, and the line C. A stagnation region is formed,
where combustible gas and combustion air is remaining in a room above the waste. The formed region enables the flame to keep stable and to exist steadily. Furthermore, mixing the combustible gas with the combustion air is promoted, to facilitate uniform and stable combustion, so that the generated amount of the NOx and CO reduces to a great extent.

[0021] In the region below the line A, the oxygen amount is insufficient, and a low temperature of the blown gas causes the combustion of the combustible gas to be unstable, resulting in increasing the generated amount of CO.

[0022] In the region above the line B, high-temperature combustion is done, so that decomposing the waste thermally or gasifying the waste promotes excessively, and the combustible gas burns in a limited part to increase NOx.

[0023] In the region below the line C, even in case that the gas is blown into, gas mixing is not done sufficiently. The reason why is that the wound gas around the blown gas and the agitation effect are small. As a result, a high-temperature region is formed in a limited part, and thus the generated amount of NOx increases.

[0024] Following the example, in case that the oxygen concentration in the high-temperature gas is 12%, the temperature of the high-temperature gas that attains both low value of NOx and low value of CO is fallen within a range of 280 to 500°C. In case that the oxygen concentration in the high-temperature gas is 15%, the temperature of the high-temperature gas that attains both low value of NOx and low value of CO is fallen within a range of 200 to 330°C.

[0025] In the combustion chamber, a room in which the temperature is 400°C or higher and the combustible gas exists is a region for decomposing the waste thermally promotes, or the room is the region for decomposing the waste thermally completes. And the region for generating the combustible gas by decomposing the waste thermally and the region where the flame exists. For example, paper refuse begins to decompose thermally at about 250°C, the and ends up decomposing at about 400°C. Plastic refuse, the begins to decompose thermally at about 400°C and ends up decomposing at about 500°C. Even in case that the high-temperature gas is blown into a region, in which no decomposing the waste thermally begins and merely drying is done, an effect on promoting a low value of NOx and a low value of CO within the exhaust gas is slight. Therefore, the region for blowing the high-temperature gas exists, preferably as a room in which the room temperature is 400°C or higher and the combustible gas exists.

[0026] As described above, the high-temperature gas is preferable to be blown into a region in which a lot of combustible gas exists. However, in case of most of the waste incinerators such as a stoker type or a fluidizedbed type, the region in which a lot of combustible gas exists is fallen within a range, which is, from the region for starting combustion to the main combustion region. Here, the term "a region for starting combustion" means one, in which decomposing thermally or oxidizing partially enables the waste to generate the combustible gas, and in which the waste starts burning.

[0027] In addition, the term "a main combustion region" is defined as one, in which decomposing the waste thermally, oxidizing the waste partially and burning the waste are done, simultaneously with generating the combustible gas and with burning the waste with flame. And the main combustion region ends up until the point at which the combustion with the flames completes. (A Burn-off point). Therefore, the region for blowing the high-temperature gas is preferably fallenwithin a range from the region for starting combustion to the main combustion region. In the stoker incinerator, the region for starting combustion is a room, which is located above a drying stoker, and the main combustion region corresponds to a room, which is located above a burning stoker.

[0028] Generally, the term "primary combustion air" is defined as combustion air that is blown from a wind box under a stoker in case of the stoker incinerator, and from a wind box under a fluidized bed in case of the fluidized bed incinerator. In the present invention, the amount of the high-temperature blown gas is preferable to be 10 to 70% as much as the amount of the primary combustion air for the reason described below. In case that the amount of the high-temperature blown gas is smaller than 10% as much as the amount of the primary combustion air, the high-temperature gas does not have a momentum enough to agitate the in-furnace gas. Consequently, it may be a case, it brings up unsatisfactory effects to blow the high-temperature gas. In addition, in case that the amount of the high-temperature blown gas exceeds 70% as much as the amount of the primary combustion air, the respective effects on low-NOx and low-Co by the exhaust gas saturates. Therefore, not only it becomes meaningless to increase the amount of the high-temperature blown gas, but also it is in vain to increase the amount of the exhaust gas. As a result, large-sized equipment becomes necessary in order to treat the exhaust gas.

[0029] In case that the amount of the primary combustion air used as a reference value for the amount of high-temperature blown gas is smaller than the theoretical amount of the theoretical air, which is required for completing the combustion of the waste, the amount of the high-temperature blown gas is preferably 10 to 70% as much as the amount of theoretical air for burning the waste. The amount of the theoretical air is determined from the viewpoint of the properties that the waste possesses.

[0030] The combustible gas generated from the waste usually flows upward. Therefore, in case that the direction in which the high-temperature gas is blown into in the upward direction, the respective flows of the combustible gas and the high-temperature gas have the respective velocity component in the same direction. As a result, agitating and remaining invites less effect on the combustible gas. It becomes less effect on the waste to blow the high-temperature gas. Contrarily, in case that the high-temperature gas is blown into in the horizontal direction or the downward one, it becomes easy for the rising combustible gas to mix well with the high-temperature gas. Furthermore, it becomes easy for the flow of combustible gas to remain, so blowing the high-temperature gas enhances the effects.

[0031] Blowing the high-temperature gas as a swirl flow makes it possible to enhance the effects by mixing. And such blowing makes it possible to enhance the effects by blowing the high-temperature gas. Here, "blowing high-temperature gas as a swirl flow" is defined as follows. That is, it may be a case, the high-temperature gas itself, which flows out of an opening for blowing out the gas forms a swirl flow. And, it may be a case, a plurality of the high-temperature gas, which flow out of a plurality of the opening for blowing out the gas, are combined into a swirl flow.

[0032] As mentioned above, in accordance with the present invention, a method for operating a waste incinerator can easily realize, making use of a stoker-type waste incinerator or a fluidized bed-type one. Such an incinerator has equipment for circulating an exhaust gas, which means, for blowing the exhaust gas into the furnace while circulating. Here, the air is mixed with the exhaust gas to regulate the properties of the high-temperature gas, and the device controls the oxygen concentration and the temperature of the high-temperature gas that is blown into the range that exists from the region for starting combustion to the main combustion region in the furnace.

[0033] In such a waste incinerator, in case that a nozzle for blowing the high-temperature gas into the furnace is located at a position not exceeding 1/2 as high as the whole height of a combustion chamber, a stagnation region is formed just above the waste layer in the furnace by the high-temperature gas blown through the nozzle. As a result, the stagnation region causes the flame to remain steadily just above the waste layer in the furnace. Therefore, it is efficiently done to decompose the waste thermally. Furthermore, the high-temperature region becomes farther away from the ceiling of the furnace, so that the ceiling has even less possibility to receive the damage by the burnout.

[0034] The term "combustion chamber height" is defined as a height of a room in which the main combustion is done. That is, a height has a distance from the stoker or the fluidized bed to the ceiling, or the height has a distance from the stoker or the fluidized bed to a position at which the secondary combustion air is blown.

[0035] Fig.3 shows one example of the waste incinerators, in accordance with the present invention.

[0036] On one side (left-hand side in Fig. 3) of a combustion chamber 1, a hopper 2 is located to charge waste 3 into the combustion chamber 1. At the bottom of the combustion chamber 1, a stoker for burning the waste 3, simultaneously with moving the waste, is located. The stoker inclines downward in accordance with the distance from the hopper 2. The stoker has two different step, which are formed in the furnace. And the stoker is divided into three stages. Such three stages, which is respectively constituted with the stoker, are named for a drying stoker 4, for a burning stoker 5, and for an after burning stoker 6 from the hopper side. On the drying stoker 4, drying and igniting the waste 3 are mainly done. On the burning stoker 5, burning the waste 3 is mainly done. On such a burning stoker 5, the waste 3 burns to be decomposed thermally, resulting in generating the combustible gas together with the combustion gas. On the burning stoker 5, burning the waste 3 completes substantially. On the after burning stoker 6, the unburned combustibles in the waste 3 that remains in the waste 3 to a slight extent completes burning. Acombustion residue after the complete combustion is discharged through a main ash chute 7.

[0037] Under the respective stokers, a windbox 8, which is connected with a supply pipe for supplying combustion air, is located.

[0038] At the lower and upper parts of the combustion chamber 1, where the combustion chamber 1 is located on the opposite side of the hopper 2, a main flue 9 and a bypass flue 10 are located. Such flues are connected with a secondary combustion chamber 12 of a waste heat boiler 11, which has a role as a part of gas cooling equipment. In the combustion chamber 1, a barrier (intermediate ceiling) 13 for dividing the combustion gas is located near the outlet of the combustion chamber 1. The barrier (intermediate ceiling) 13 separates the flow of the combustion gas into the main flue 9 and the bypass flue 10.

[0039] The waste 3 is charged into the combustion chamber 1 through the hopper 2, and the waste 3 is dried. And then, the waste burns, simultaneously with supplying the combustion air to the waste 3 and simultaneously with moving the waste on the stokers through the respective supply pipes and the respective wind boxes 8.

[0040] Nozzles 14 are located in the sidewalls of the combustion chamber 1. From such nozzles 14, the high temperature gas, whose temperature is 200°C or higher and satisfies the above-described equation (1) , is blown into the combustion chamber 1. The nozzles 14 are located above the drying stoker 4 and above the left-hand side of the burning stoker 5. When incinerating the waste 3, water evaporates first and then thermal decomposition/partial oxidation takes place. Such a thermal decomposition begins at a temperature of approximately 200°C, and almost finishes at a temperature of approximately 400°C. The nozzles 14 are located at a part (rear stage part) of the drying stoker 4 and at a front stage part of the burning stoker 5 to blow the high-temperature gas. The thermal decomposition finishes at a much higher temperature, being influenced by a kind of the waste 3. In such a case, it is preferable that the nozzles 14 is also located on the rear stage side (right-hand side in Figure 3) of the position shown in Fig.3.

[0041] As described above, the nozzles 14 are preferably located at a height position, not exceeding 1/2 as high as the whole height of the combustion chamber.

[0042] In addition, as described above, blowing the high-temperature gas into a room makes it possible to promote the combustion of combustible gas, where the temperature is 400°C or higher and the combustible gas exists in the room. Therefore, the nozzles may be located in the portions of the sidewall, the ceiling, the intermediate ceiling 13, or the inlet of the secondary combustion chamber 12. Such nozzles have roles for blowing the high-temperature gas into a region, where the main flue gas mixes with the bypass flue gas that contains a lot of combustible gas. That is, for blowing the high-temperature gas into an inlet portion of the secondary combustion chamber 12 above the intermediate ceiling 13.

[0043] It is preferable that the amount of the high-temperature blown gas is as small as possible, taking an exhaust gas treatment and the like into consideration.

[0044] However, in case that the amount of the blown gas is small, CO becomes easy to generate, resulting in the impossible complete combustion. Therefore, as described above, the amount of the blown gas is preferably 10 to 70% as much as the amount of the primary air blown from the wind box 8. As a result, CO is suppressed to generate, to an extent that no troublesome matter happens. Thus, it is preferable that the amount of the blown gas is controlled so as to be fallen within a range of 10 to 70% as much as the amount of the primary air, simultaneously with monitoring the amount of the exhausted CO and NOx. In particular, it may be a case, the kind of the waste 3 influences on the amount of the blown primary air, that is, the amount of the blown primary air is smaller than the theoretical air amount necessary for burning the waste 3. In such a case, it is preferable that a lot of amount of the high-temperature gas is blown into, in order to promote the complete combustion of the waste 3 and in order to prevent CO from generating. In case that the amount of the high-temperature blown gas is small, the amount of the high-temperature blown gas may be, as described above, within a range of 10 to 70% as much as the theoretical air amount necessary for burning the waste 3.

[0045] In case that the nozzles 14 are located in the horizontal direction or in the downward one , the high-temperature gas inj ected from the nozzles causes the flow of the combustible gas to remain against the rising flow. And such remaining enhances the combustible gas to burn. From the standing point of the effects by promoting remaining, the nozzles are preferably located in the downward direction. However, in case that a downward angle of the nozzles is too large, it makes impossible for the high-temperature gas to reach the whole of the furnace along a width direction. Therefore, the downward angle is particularly preferable, fallen within a range of 10 to 20°, downward from the horizontal direction.

[0046] Fig. 4A-4C show a sectional view along the line A-A' of Fig. 3 (horizontal cross section: Fig.4A and 4B) and a sectional view along the line B-B' of Fig.3 (vertical cross section:Fig.4C), in order to show the allocation of the nozzles in Fig. 3. Fig.4A-4C, omit the structures that have no relation with the present invention.

[0047] In Fig.4A, high-temperature gases 19 are injected from a pair of nozzles 14 provided in a furnace wall 17 so as to be opposed to each other in the width direction, and collide with each other in the center of furnace. Therefore, in the central portion of the furnace, the in-furnace gas is slow to move, and a stagnation region 15 is formed, where the gas remains. As a result, a stable combustion is done.

[0048] Fig.4B shows another example. Here, the respective directions of the nozzles 14 are located in such a way that the center axes are parallel each other and separated at a predetermined interval, so that in the central portion of the furnace, the mutual high-temperature gas 19 passes by each other, apart from a predetermined distance. Therefore, a swirl region 20 is formed in the central portion of the furnace.

[0049] In such examples, the stagnation region 15 or the swirl region 20 is formed in the central portion of the furnace in a plain view. Therefore, as described above, the flame keeps stable to promote mixing of the mutual gas.

[0050] Fig.4A shows how to control the size of the stagnation region 15, changing the flow velocities of the high-temperature gas injected from the two nozzles 14 in the same way. Furthermore, the difference makes it possible to change the transverse position in the furnace, where the stagnation region 15 is formed. Here, the difference means the one in the flow velocity between one high-temperature gas injected from one side of the nozzles 14 and the other high-temperature gas injected from the other side of the nozzles 14. Furthermore, changing the directions of the nozzles 14 in the lengthwise direction of the furnace in the same direction makes it possible to change the longitudinal position in the furnace of the stagnation region 15.

[0051] In Fig.4B, changing the interval between the two nozzles 14 makes it possible to change the size of the swirl region 20. Furthermore, a difference in the flow velocity between one high-temperature gas 19 and the other high-temperature gas makes it possible to change the transverse position in the furnace, where the swirl region 20 is formed. Furthermore, changing the flow velocities of the two high-temperature gas 19 in the same way makes it possible to change the velocity of swirl flow.

[0052] Fig.4C is a vertically sectional view of the furnace. The Fig.4C shows a state to form the stagnation region 15. Here, the high-temperature gas 19 is blown from the nozzles 14, which is located slantwise downward on both sides in the furnace walls 17. The high-temperature gas 19 collides with the rising combustible gas 21 to form the stagnation region 15. In the stagnation region 15, a stable combustion is done. And resultantly a stable flame is formed. As a result, different from the prior art, unstable combustion, which happens in the region for starting the combustion, is not amplified, even at a low air excess ratio. Consequently, it prevents the soot and the like from generating, resulting in the uniform and the stable combustion.

[0053] Furthermore, in order to perform mixing, it is effective to blow the high-temperature gas into the furnace as a swirl flow, from the nozzles 14.

[0054] Furthermore, blowing the high-temperature gas has an effect on stabilizing the combustion, so as to agitate the gas near the sidewall of the furnace sufficiently. Therefore, it is preferable to keep the blowing speed as at least 10m/s or more.

[0055] The flame in the furnace is a luminous flame when high-temperature gas is not blown. But, in case that the high-temperature gas is blown appropriately into the furnace as described above, the flame in the furnace becomes transparent, so that the stoker is observed from the furnace wall. The reason why such a flame is obtained is that blowing the high-temperature gas makes it possible to burn the combustible gas slowly. Therefore, judging from the viewpoint of the transparency degree of the flame in the furnace, the criterion is applied to the process, concerning whether appropriately or not the high temperature gas is blown into the furnace.

[0056] The above-described embodiment has an effect on reducing the amount of trace hazardous substances such as CO, NOx, and dioxin.

[0057] Fig.3 illustrates a furnace that has the intermediate ceiling 13. However, it goes without saying that the present invention is applied to a furnace, which has no intermediate ceiling. And, in the exemplary embodiment, although the high-temperature gas is blown into the combustion chamber 1, it is applied to the process that the high-temperature gas is blown into the secondary combustion chamber 12. Further, it may be a case, the high-temperature gas is blown from one side of the furnace without both sides. The high-temperature gas is, also, blown from the intermediate ceiling or the ceiling, although it is applicable from the sidewall of the furnace.

[0058] In order to apply a high-temperature gas injected from the nozzle 14, it is adequate to use a mixed gas, together with circulated exhaust gas and air. The circulated exhaust gas is one part of the exhaust gas discharged from the waste incinerator, and has an effect on reducing the amount of the hazardous substances and the exhaust gas by returning the gas into the combustion chamber.

[0059] In case that the circulated exhaust gas is satisfied with the conditions of the high-temperature gas in the present invention, it may be a case, the circulated exhaust gas is blown into the furnace by itself, without mixing. However, in case that the conditions satisfy both, which means, the temperature condition is lower than 200°C and the oxygen concentration is low, it may be a case, high temperature air is produced by high-temperature air producing equipment or by a hot stove, such high-temperature air is mixed with the circulated exhaust gas, and such high-temperature gas is blown into the furnace as the high-temperature gas that satisfy the conditions of the invention.

[0060] Furthermore, in case that the conditions satisfy the both, these means, the temperature of the exhaust gas from the secondary combustion chamber 12 is sufficiently high and the oxygen concentration is high, such exhaust gas together with air is blown into the furnace. This is done, making use of such exhaust gas instead of the high temperature air, without applying the high-temperature air producing equipment. Furthermore, in case that the temperature of the exhaust gas from the secondary combustion chamber 12 is 200°C or higher, and the relationship between the oxygen concentration and temperature satisfies the above-described equation (1), such exhaust gas is blown directly into the furnace.

[0061] In case that the exhaust gas generating from the incinerator is used as the whole or as the partial amount of the high-temperature gas, sodium salt, potassium salt and the like in dust, which the exhaust gas contains, adhere to the wall of pipes. Consequentlly, there has a possibility to occur the corrosion and to clog the pipes. Furthermore, in case that the exhaust gas is blown into the furnace without removing dust, the danger is predicted that the concentration of the exhausted hazardous substances rather increases by the hazardous substances (for example, dioxin), which is contained in the dust. Therefore, it is preferable that the dust in the exhaust gas is removed. As a method for removing the dust, the filter method and the cyclone method, which are well known to the world, are applicable. The filter method has one using a filter cloth and the other using a ceramic filter. In case that the temperature of the exhaust gas is high, the ceramic filter is preferable from the viewpoint of the durability and the heat resistance. The filter cloth, which is fabricated from metallic fibers, is also effective, in such a case, it is influenced by the service temperature. Furthermore, a moving bed type dust eliminator is usable. It is preferable that the dust is removed as close as possible to the take-off port, in order to shorten the length of the pipes, which is located between the take-off port and the dust-removing device.

[0062] It is desirable to take off the exhaust gas from a part, at which the temperature of the exhaust gas is high. In case of the incinerator with a waste heat boiler, it is effective to take off the exhaust gas from the boiler. The boiler, makes it possible to take off the exhaust gas, whose temperature is 800°C. Furthermore, such a high-temperature gas enables high-temperature hazardous substances to be removed effectively. As high-temperature air producing equipment, for example, the equipment, in which air or oxygen is mixed with the combustion gas from a regenerative burner or a combustion burner of a recuperator or a hot stove, is usable. The regenerative burner is a device that provides a pair of heat reservoirs. The first heat reservoir is heated by the high-temperature exhaust gas from a combustion burner. And, air is sent into the second heat reservoir that was previously heated, is heated. In the regenerative burner, it is possible to switch over the heating of heat reservoir by the high-temperature exhaust gas and the heating of air by heat reservoir.

[0063] In case that the high-temperature gas from the high-temperature air producing equipment is mixed with the circulated exhaust gas, an ejector is preferably used for mixing the gas with the air and for blowing into the furnace. That is to say, the high-temperature gas is introduced into the ejector, and is used as a driving flow for mixing with the circulated exhaust gas, simultaneously with sucking, and the mixed gas is blown into the furnace. Such a device makes it possible to require no special movable section such as a fan for sucking the circulated exhaust gas, so that the system configuration becomes simple. And, there becomes much less possibility to invite dust trouble.

[0064] Table 1 shows the countermeasures taken by the operational factors and by the operational method, in order to improve the characteristic of the high-temperature gas that is blown into the furnace. Such countermeasures are taken, in case that burner combustion gas from the hot stove, diluted air, and circulated exhaust gas are mixed together for preparing the high-temperature gas to be blown into the furnace. At the same time, such countermeasures are taken, in case that the characteristic of the high-temperature gas blown into the furnace (oxygen concentration and temperature) is fallen without a range of the present invention. Following the example, in case that the oxygen concentration is lower than the range of the present invention and in case that the temperature is higher than the range of the present invention, the amount of the diluted air is forced to increase, the following countermeasure is taken. That is, the amount of the combustion burner is forced to increase in order to rise the temperature of the high-temperature gas. At the same time, the amount of the circulated gas is forced to decrease, simultaneously with increasing the amount of the diluted air (the amount of the air mixed into the high-temperature gas). Consequently, the results of the countermeasures become to be fallen within a conditional range that the present invention satisfies. In case that the oxygen concentration is lower than the range of the present invention, and in case that the temperature is higher than the range of the present invention, merely the amount of the diluted air is forced to increase, resulting in increasing the oxygen concentration.

Table 1

Characteristic of blown gas (comparison with range of the present invention)		Operational factors and operating method		
Oxygen concentration	Temperature	Combustion amount of hot stove burner	Amount of diluted air	Amount of circulated exhaust gas
Low	Low	Increase	Increase	Decrease
	High	-	Increase	-
High	Low	Increase	Decrease	Increase
	High	Decrease	Decrease	Increase

[0065] As mentioned above, the example was shown, in which the high-temperature gas is blown so as to form the stagnation region or the swirl region in the furnace. As described in the prior art, such an operation is preferable to stabilize combustion. However, the object of the present invention, is stabilizing combustion in the range from the region for starting the combustion to the main combustion region. So, in case that the temperature and the oxygen concentration of the high-temperature gas is fallen within the range of the present invention, the high-temperature gas are not always necessary to be blown so as to form the stagnation region or the swirl region.

[0066] Fig.5 shows one example of the exhaust gas circulation systems in the waste incinerator, in accordance with the present invention.

[0067] As Fig. 5 shows in detail, the exhaust gas from the combustion chamber 1 is introduced into the waste heat boiler 11, and subj ected to secondary combustion in the secondary combustion chamber 12, which is a part of the waste heat boiler 11. Thereafter, the heat that the gas holds is exchanged by the waste heat boiler 11, the gas is purified by exhaust gas treating equipment 22, and the gas is discharged into atmospheric air through a stack 23.

[0068] In such a process, a part of the exhaust gas is sucked by a blower 24 from the downstream side of the exhaust gas treating equipment, and is introduced into a gas mixer 25. The high-temperature combustion gas such as burner combustion gas is introduced into the gas mixer 25 via a high-temperature combustion gas regulating valve 26, simultaneously with introducing the diluted air into the gas mixer 25 via a diluted air regulating valve 27. In the gas mixer 25, the exhaust gas, the high-temperature combustion gas, and the diluted air are mixed together in order to prepare the high-temperature gas. The high-temperature gas is blown into the combustion chamber 1. An oxygen concentration controller 29 controls the oxygen concentration in the high-temperature gas. In the oxygen concentration controller 29, the opening of the diluted air regulating valve 27 is regulated so that the oxygen concentration in the high-temperature gas keep a predetermined value. Furthermore, a temperature controller 28 controls the temperature of the high-temperature gas. In the temperature controller 28, the opening of the high-temperature combustion gas-regulating valve 26 is regulated so that the temperature of the high-temperature gas exists within the range shown by the above-described equation (1).

[0069] Thus, the process has a function for controlling the oxygen concentration and the temperature in the high-temperature gas blown into the combustion chamber. So, the oxygen concentration and the temperature in the high-temperature gas blown into the combustion chamber are kept in an appropriate range. In case that it is desired to regulate the flow rate or the flow velocity of the high-temperature gas being blown, the rotational speed of the blower 24 has only to be controlled.

[0070] Fig. 6 shows another example of the exhaust gas circulation systems shown in Fig. 5. The example is different from the example shown in Fig. 5, merely from the viewpoint of the position, which is, an outlet of the waste heat boiler 11, where the exhaust gas is taken off.

[0071] In the example shown in Fig.5, the exhaust gas is taken off from the rear of the exhaust gas treating equipment 22, the dust in the exhaust gas is removed, and the exhaust gas becomes clean. However, in the situation, the temperature of the exhaust gas remains as a decreased one.

[0072] On the other hand, in the example shown in Fig. 6, the exhaust gas is taken off from the outlet of the waste heat boiler 11. Therefore, the temperature of the exhaust gas is high. However, the exhaust gas contains the dust. Therefore, the exhaust gas is sent to the blower 24 after a dust eliminator 30, located in a pipe running to the blower 24 removes the dust.

[0073] In the case of Fig.6, the temperature of the exhaust gas is high, the high-temperature combustion gas manufacturing equipment and the high-temperature combustion gas-regulating valve 26 are omitted.

[0074] In the examples shown in Fig.5 and Fig.6, the high-temperature combustion gas such as the burner combustion gas and the diluted air are mixed with the circulated exhaust gas. However, the high-temperature air produced by the above-described high-temperature air manufacturing equipment is also be introduced into a gas combustor, instead of the high-temperature combustion gas. In such a case, instead of introducing the diluted air into the gas mixer to control, the amount of air introduced into the high-temperature air manufacturing equipment is also regulated to control the oxygen concentration in the high-temperature gas.

Embodiment 2

[0075] The inventors also found out an effective method for operating a waste incinerator. That is, it is effective to contain at least one of carbon dioxide and water vapor in the high-temperature gas, in order to sufficiently reduce hazardous substances such as NOx and CO, when the high-temperature gas is blown into the combustion chamber. The reason why such a method is effective is that stable combustion is done, even in case that the combustion is done at a low air excess ratio. In the exemplary method, since the radiation ratio of carbon dioxide and water vapor is higher than that of nitrogen and oxygen, the waste and the combustible gas generating from the waste are heated efficiently by the heat radiation from the high-temperature gas, which contains such gas

[0076] As the same as embodiment 1, it was investigated how the generating CO and the generating NOx, when the high-temperature gas is blown into the combustion chamber, are associated with the oxygen concentration and the temperature of the high-temperature gas blown into the combustion chamber. As a result, shown in Fig. 7 , under the condition that the oxygen concentration in the high-temperature gas and the temperature of the high-temperature gas are controlled so as to be in a region bounded by the line A, the line B, and the line C, that is, under the condition that the temperature of the high temperature gas is 200°C or higher and the temperature satisfies the above-described equation (2), it was clearly found out that both of CO and NOx in the exhaust gas decrease at the same time. In Fig. 7, the line A is defined as $T = \exp(8.05 - 0.23C)$, the line B as $T = \exp(7.40 - 0.09C)$, and the line C as $T = 200$.

[0077] Following the example, in case that the oxygen concentration in the high-temperature gas is 12%, the temperature of the high-temperature gas, which attains both of low-NOx and low-CO , is fallen within a range of 200 to 550°C. In case that the oxygen concentration in the high-temperature gas is 15%, the temperature of the high-temperature gas, which attains both of low-NOx and low-CO, is fallen within a range of 200 to 400°C.

[0078] It is effective that a high-temperature gas containing at least one of carbon dioxide and water vapor is applied to use the exhaust gas discharged from the combustion furnace.

[0079] As the same as embodiment 1, a region, in which the high-temperature gas is blown, is a room, where the temperature is 400°C or higher and where the combustible gas exists. And the region is preferably a range that falls within from the one for starting the combustion to the main combustion one.

[0080] Furthermore, in case that the configuration of the waste incinerator includes a usable waste heat boiler, and in case that high-temperature gas contains the gas introduced from the passage of the waste heat boiler or from the outlet of the waste heat boiler, the sensible heat in the exhaust gas is utilized effectively. Consequently, the thermal efficiency increases.

[0081] Furthermore, in case that the configuration of the waste incinerator includes an exhaust gas treating equipment, and in case that the high-temperature gas is used, whose temperature is 800°C or lower and which is introduced from the upstream side of the exhaust gas treating equipment, the sensible heat in the exhaust gas is utilized effectively, similarly mentioned above. Consequently, the thermal efficiency increases.

[0082] The method for operating the waste incinerator in accordance with the present invention realizes the waste incinerator such as Fig.3, which has been described above.

[0083] In the method of the present invention, the contents of embodiment 1 are applicable, except the following situation. These are, the high-temperature gas is blown into the combustion chamber 1 through the nozzles 14 provided in the side walls of the combustion chamber 1, where the gas contains at least one of carbon dioxide and water vapor, the gas has a temperature of 200°C or higher, and the gas satisfies the above-described equation (2).

Embodiment 3

[0084] Embodiments 1 and 2 showed that the temperature of high-temperature gas blown into the combustion chamber is 200°C or higher. Even furthermore, the inventors found out that there are conditions that suppress the amount of the generating CO and dioxin, even in case that the temperature is lower than 200°C.

[0085] That is to say, in case that the waste contains biomass and woodchip, the thermal decomposition begins, in general, at the temperature of 100°C or higher, so that even in case that the temperature is lower than 200°C, the thermal decomposition happens, and the combustible gas generates. Therefore, under the condition that the temperature and the oxygen concentration of the high-temperature gas are adequate, it brings up an effect to reduce CO and dioxin. In such a case, the effect on reducing NOx is smaller than that of the case where the high-temperature gas has a temperature of 200°C or higher. But, it may be a case, a NOx removal system makes it possible to reduce NOx value.

[0086] Fig.8 shows the relationship between the temperature and the oxygen concentration of the high-temperature gas. It was found out clearly that the following conditions make it possible to promote the thermal composition of the waste andmake it possible to keep the stable flame on the layer of the waste. These are to say, by blowing the high-temperature gas having the oxygen concentration and the temperature in a region bounded by the line A, the line B, and the line C, the conditions satisfy that the temperature of the high-temperature gas is lower than 200°C, simultaneously with satisfying the above-described equation (3).

[0087] In such a case, the combustible gas promotes to be mixed burning (so-called mixed combustion) at the same time, so that uniform and stable combustion is done, resulting in reducing the generation of hazardous substances such as CO and dioxin.

[0088] In Fig.8, the line A is defined as T = exp (7.78 - 0.18C), the line B as C = 21, and the line C as T = 200.

[0089] The reason why the oxygen concentration is 21% or lower is that an oxygen concentration exceeding 21% requires oxygen enrichment equipment. So, it is not preferable.

[0090] Furthermore, in case that the temperature of the high-temperature gas is lower than 200°C as well as embodiment 2, it is effective to force the high-temperature gas to contain at least one of carbon dioxide and water vapor in the high-temperature gas, in order to suppress the generation of CO and dioxin.

[0091] In such a case, Fig. 9 shows that the temperature and oxygen concentration of the high-temperature gas are controlled so as to be in a region bounded by the line D, the line E, and the line F. That is to say, it becomes necessary that the temperature of the high-temperature gas is lower than 200°C and satisfies the above-described equation (4). In Fig. 9, the line D is defined as T = exp (8.05 - 0.23C), the line E as C = 21, and the line F as T = 200.

[0092] In case that the temperature of the high-temperature gas is lower than 200°C as well as the above-mentioned embodiment 1, the description in embodiment 1 is applicable, except the conditions for the high-temperature blown gas.

Claims

1. A method for operating a waste incinerator comprising a step of blowing high-temperature gas having a temperature T[°C] of 200°C or higher into a combustion chamber of the waste incinerator and satisfying the following equation (1);

$$\exp(7.78 - 0.18C) \leqq T \leqq \exp(7.45 - 0.11C) \quad (1)$$

wherein, C expresses oxygen concentration (vol.%) in the high-temperature gas.

2. The method according to claim 1, wherein a region for blowing the high-temperature gas is 400°C or higher, and wherein combustible gas exists in a room of the waste incinerator.

3. The method according to claim 1, wherein the region for blowing the high-temperature gas is fallen within a range from a region for starting combustion to a main combustion region.

4. The method according to claim 1, wherein the amount of the high-temperature blown gas is 10 to 70% of the amount of primary combustion air.

5. The method according to claim 1, wherein the amount of the high-temperature blown gas is 10 to 70% of theoretical air amount for burning waste.

6. The method according to claim 1, wherein a blowing direction of the high-temperature gas is in a horizontal direction or in a downward direction.

7. The method according to claim 1, wherein the high-temperature gas is blown as a swirl flow.

8. A method for operating a waste incinerator comprising a step of blowing high-temperature gas that contains oxygen and at least one selected from the group consisting of carbon dioxide and water vapor, into a combustion chamber of the waste incinerator, wherein a temperature of the high-temperature gas T [°C] is 200°C or higher, and wherein the temperature of the high-temperature gas T [°C] satisfies the following equation (2);

$$\exp(8.05 - 0.23C) \leqq T \leqq \exp(7.40 - 0.09C) \quad (2)$$

wherein, C expresses oxygen concentration (vol.%) in the high-temperature gas.

9. The method according to claim 8, wherein a region for blowing the high-temperature gas is 400°C or higher, and wherein combustible gas exists in a room of the waste incinerator.

10. The method according to claim 8, wherein the region for blowing the high-temperature gas is fallen within a range from a region for starting combustion to a main combustion region.

11. The method according to claim 8 further comprising a step of using a waste incinerator having a waste heat boiler, wherein the high-temperature gas contains gas introduced from a passage of the waste heat boiler or from an outlet of the waste heat boiler.

12. The method according to claim 8 further comprising a step of using a waste incinerator having equipment for treating exhaust gas, wherein the high-temperature gas contains gas of 800°C or lower, and wherein the high-temperature gas is introduced from an upstream side of the equipment for treating exhaust gas.

13. A method for operating a waste incinerator comprising a step of blowing high-temperature gas having a temperature T[°C] of lower than 200°C into a combustion chamber of the waste incinerator and satisfying the following equation (3);

$$\exp(7.78 - 0.18C) \leqq T \quad (3)$$

wherein, C expresses oxygen concentration(vol.%) in the high-temperature gas.

14. A method for operating a waste incinerator comprising a step of blowing high-temperature gas that contains oxygen and at least one selected from the group consisting of carbon dioxide and water vapor into a combustion chamber of the waste incinerator, wherein the temperature T[°C] of the high-temperature gas is lower than 200°C, and wherein the temperature T[°C] of the high-temperature gas satisfies the following equation (4);

$$\exp(8.05 - 0.23C) \leqq T \quad (4)$$

wherein, C expresses oxygen concentration (vol.%) in the high-temperature gas.

15. A stoker or fluidized bed waste incinerator having equipment for circulating exhaust gas to blow the exhaust gas into a furnace of the waste incinerator during being circulated,

wherein, the equipment for circulating the exhaust gas provides a controlling device for controlling high-temperature gas by mixing air with the exhaust gas, for controlling oxygen concentration and temperature of the high-temperature gas blown into a range inside the furnace, wherein the region is fallen from a region for starting combustion to a main combustion region in the furnace.

16. An apparatus according to claim 15, wherein nozzles for blowing the high-temperature gas into the furnace are located at a position not exceeding 1/2 as high as the whole height of a combustion chamber.

FIG. 1

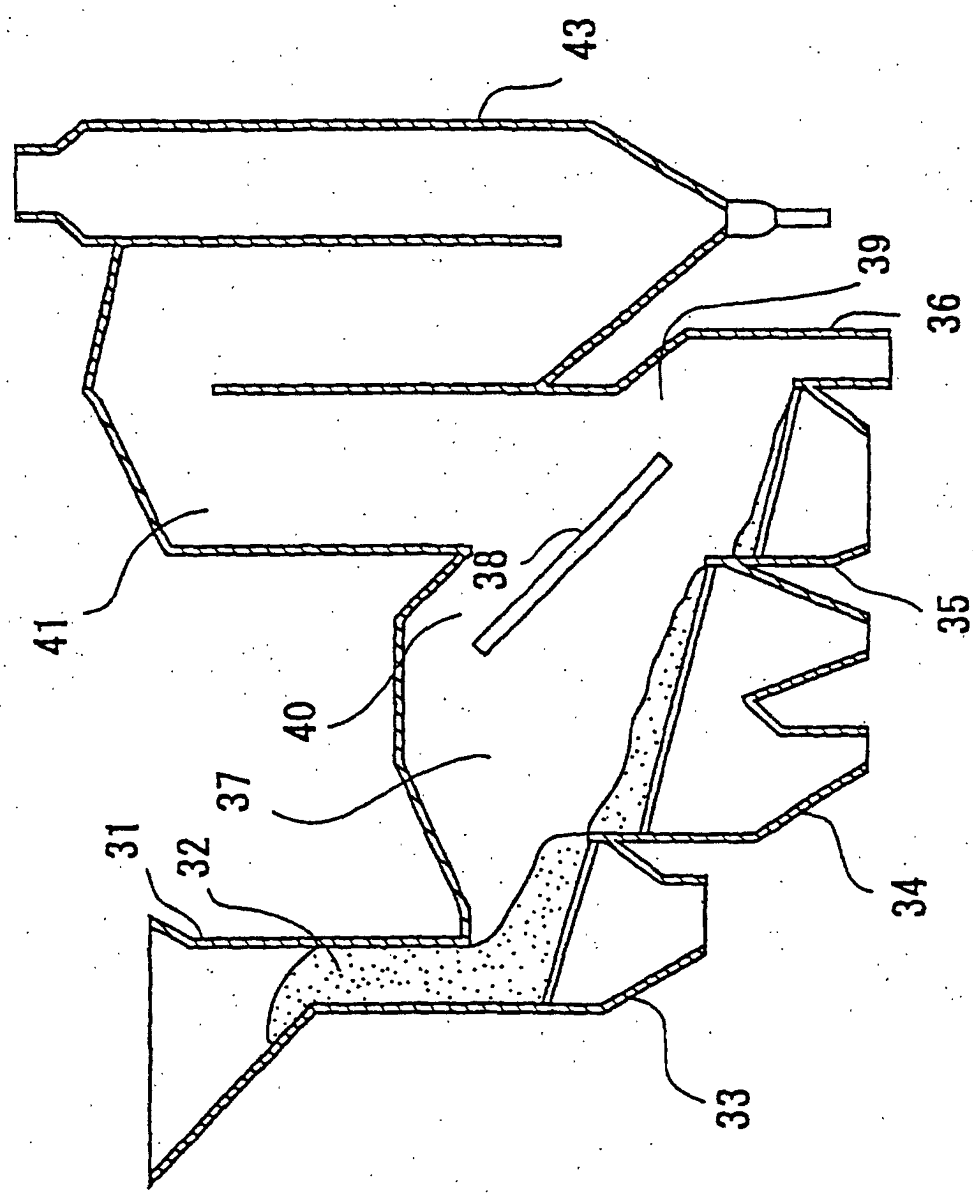
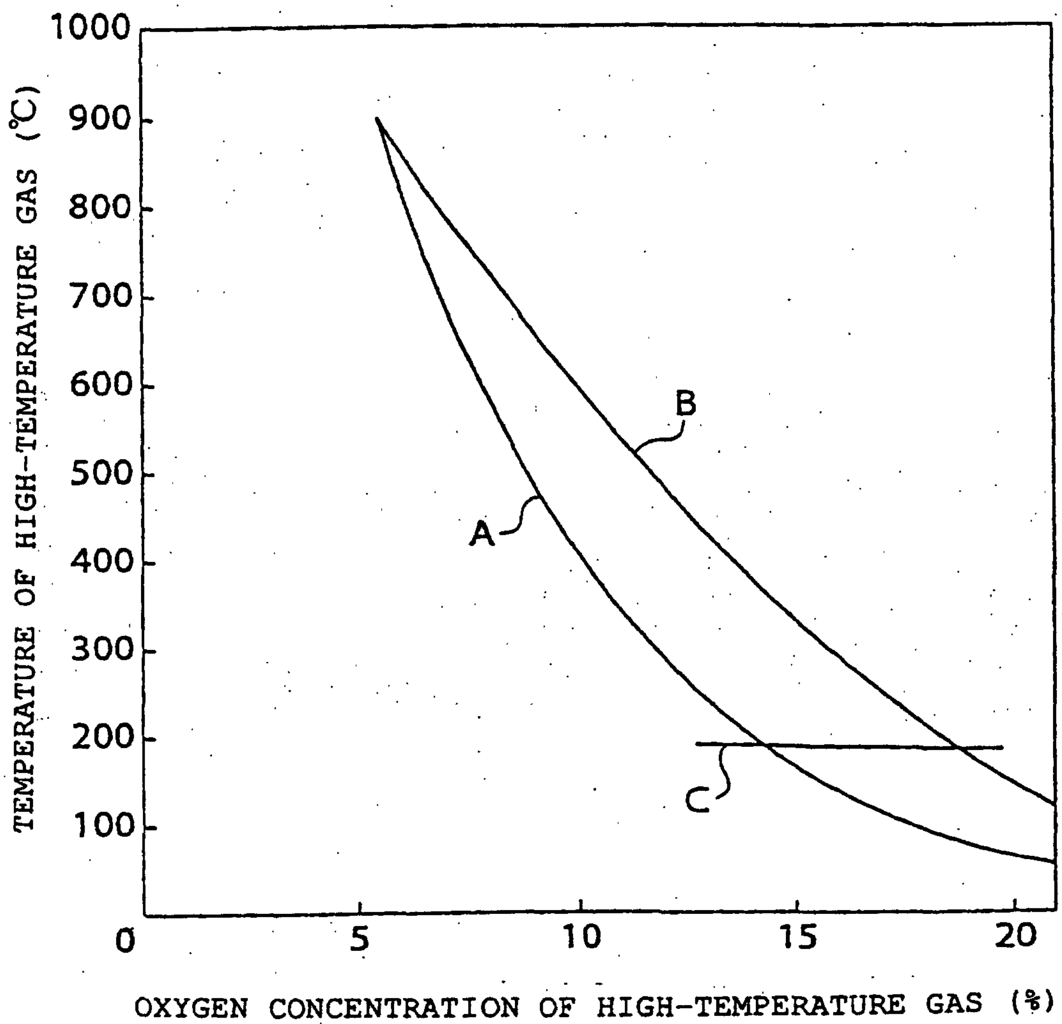


FIG. 2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400
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0
5
10
15
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TEMPERATURE OF HIGH-TEMPERATURE GAS (℃)
OXYGEN CONCENTRATION OF HIGH-TEMPERATURE GAS (%)
A
B
C

FIG. 3

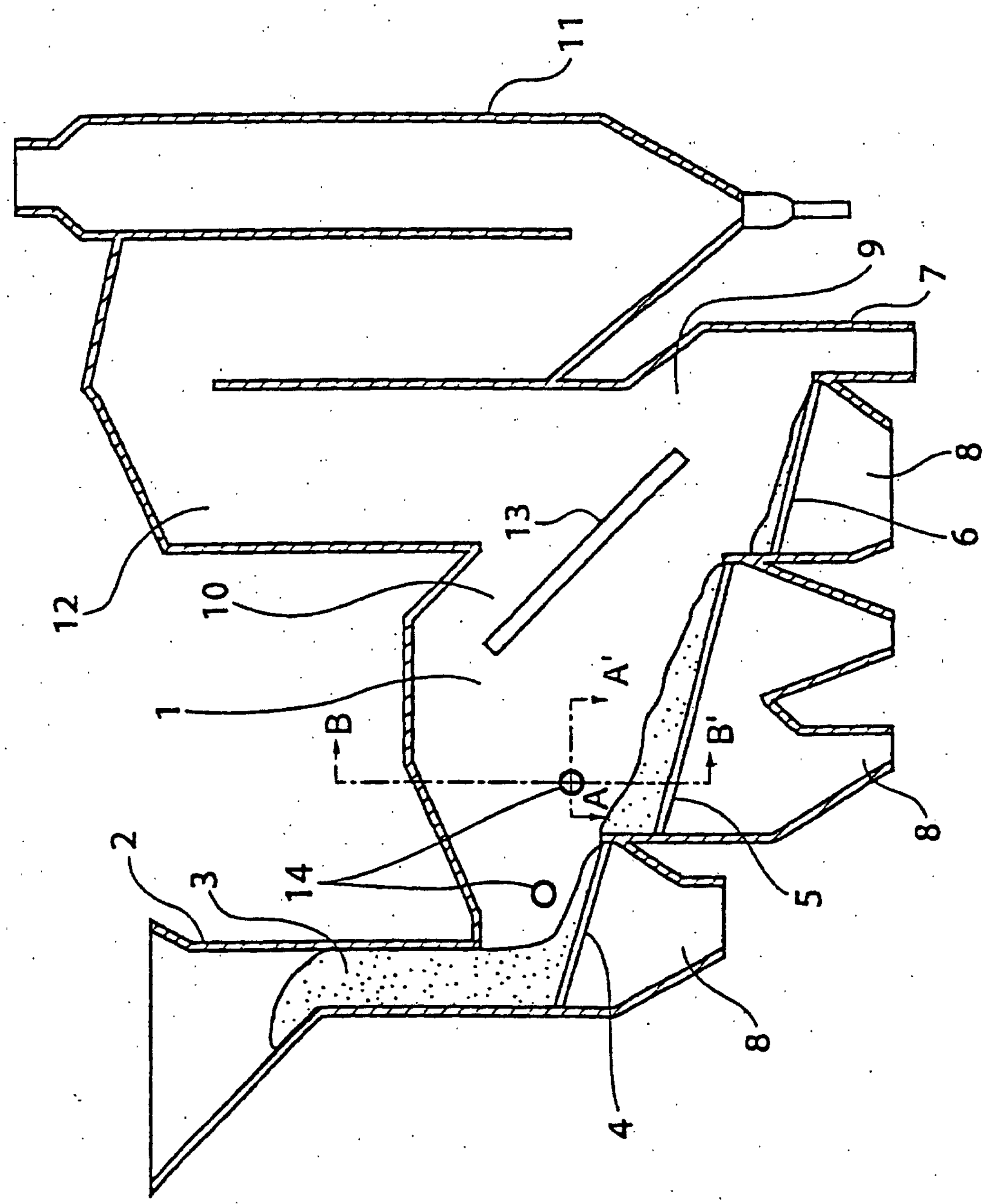


FIG. 4A

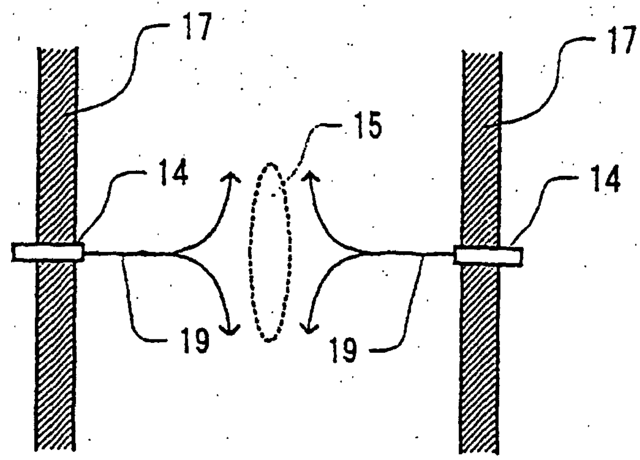


FIG. 4B

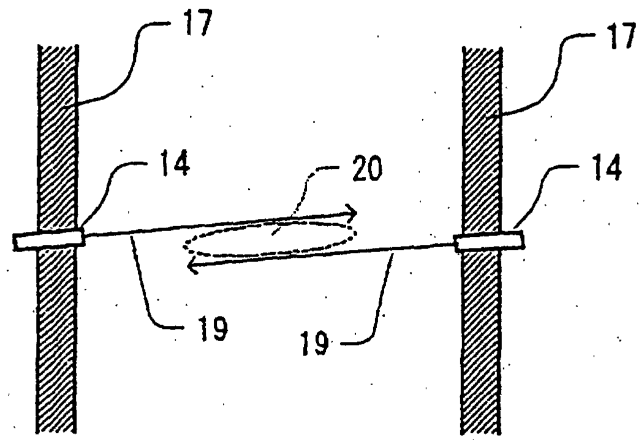


FIG. 4C

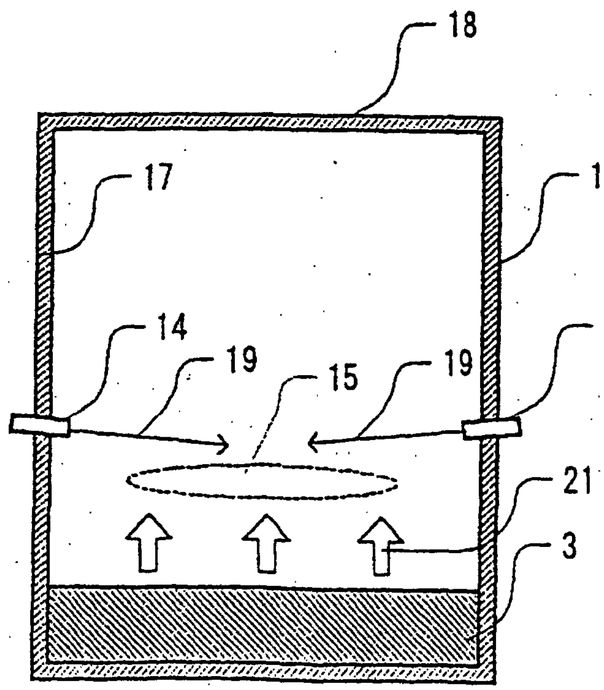
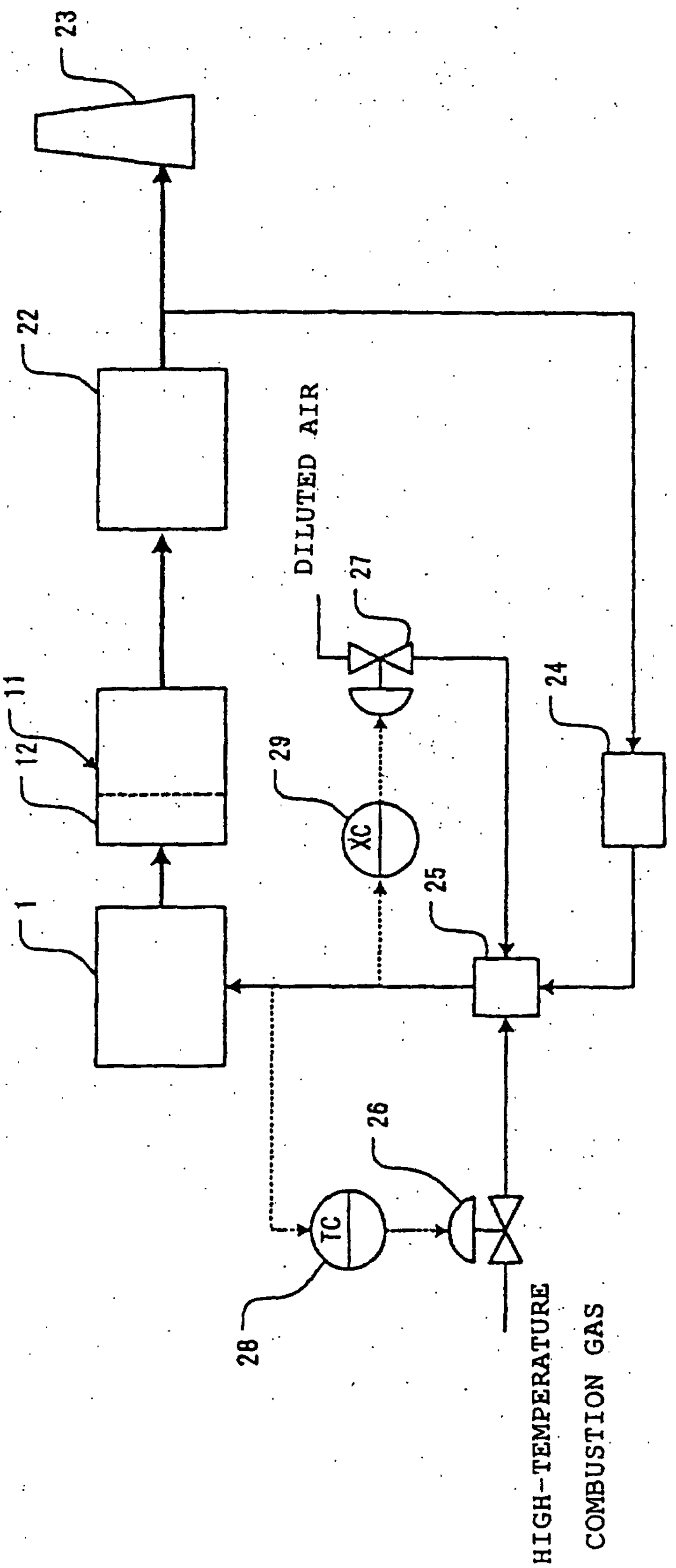


FIG. 5


23
22
12
11
1
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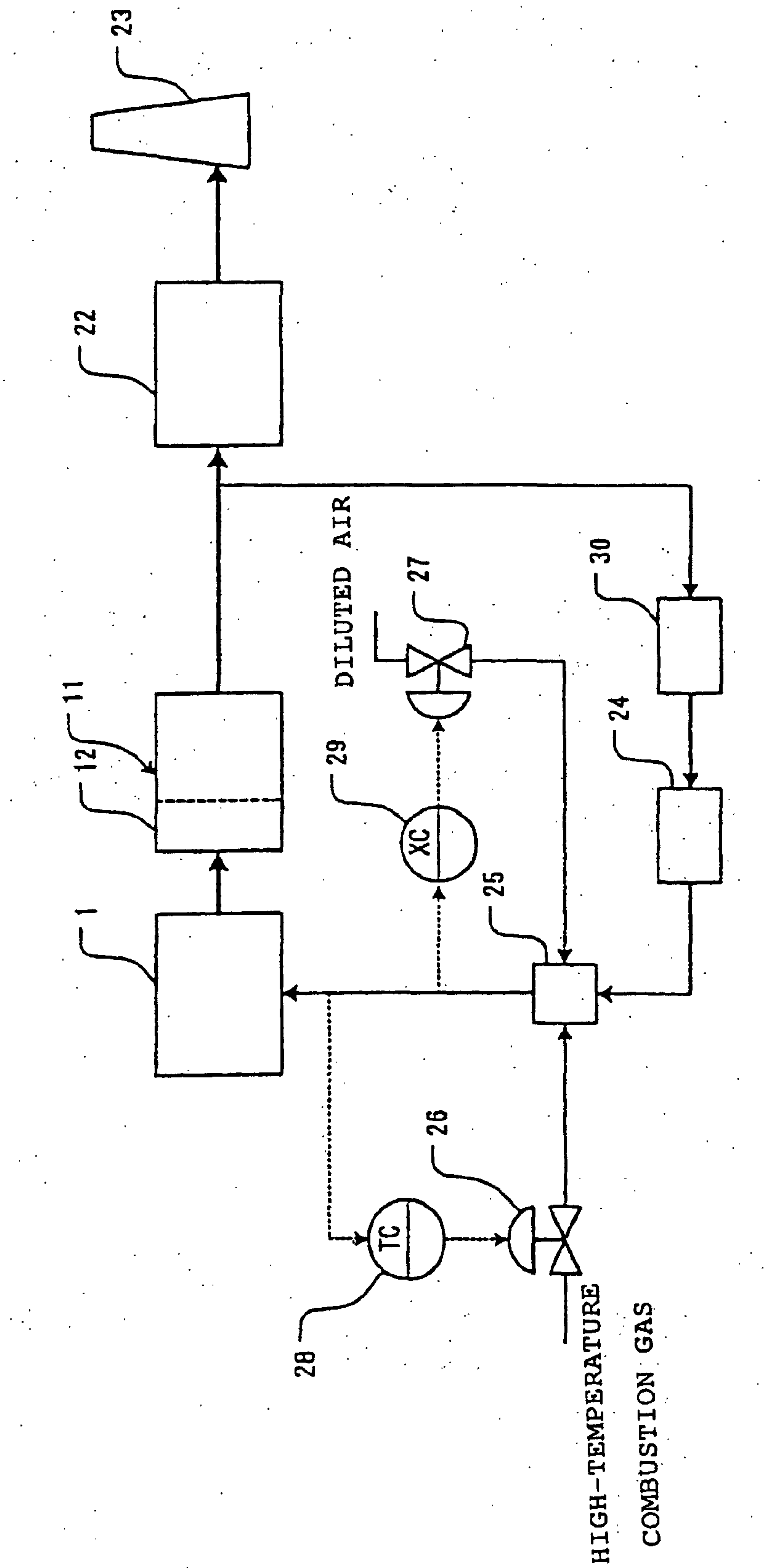
29
XC
24
25
26
TC
28
HIGH-TEMPERATURE
COMBUSTION GAS

FIG. 6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30
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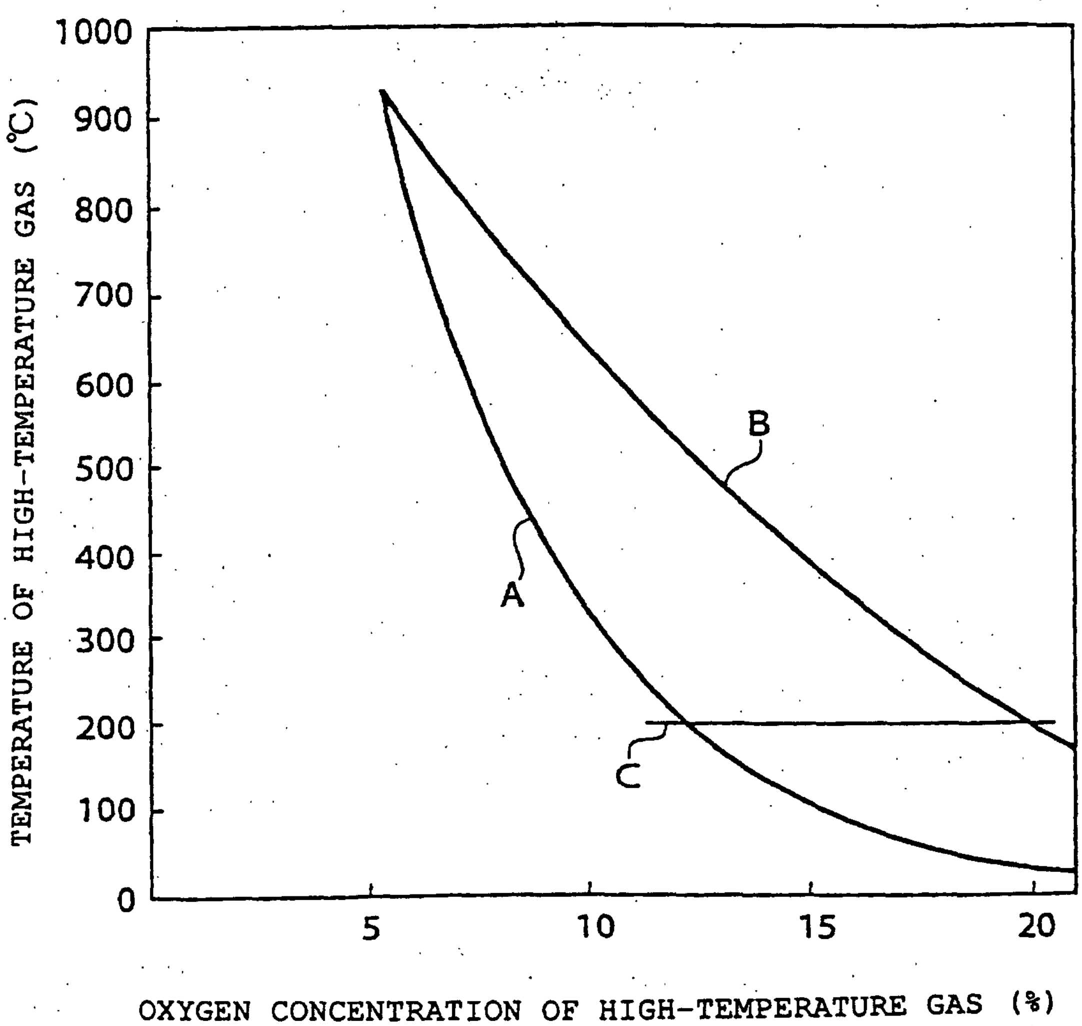
COMBUSTION GAS

FIG. 7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400
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200
100
0
TEMPERATURE OF HIGH-TEMPERATURE GAS (℃)
B
A
C
5
10
15
20
OXYGEN CONCENTRATION OF HIGH-TEMPERATURE GAS (%)

FIG. 8

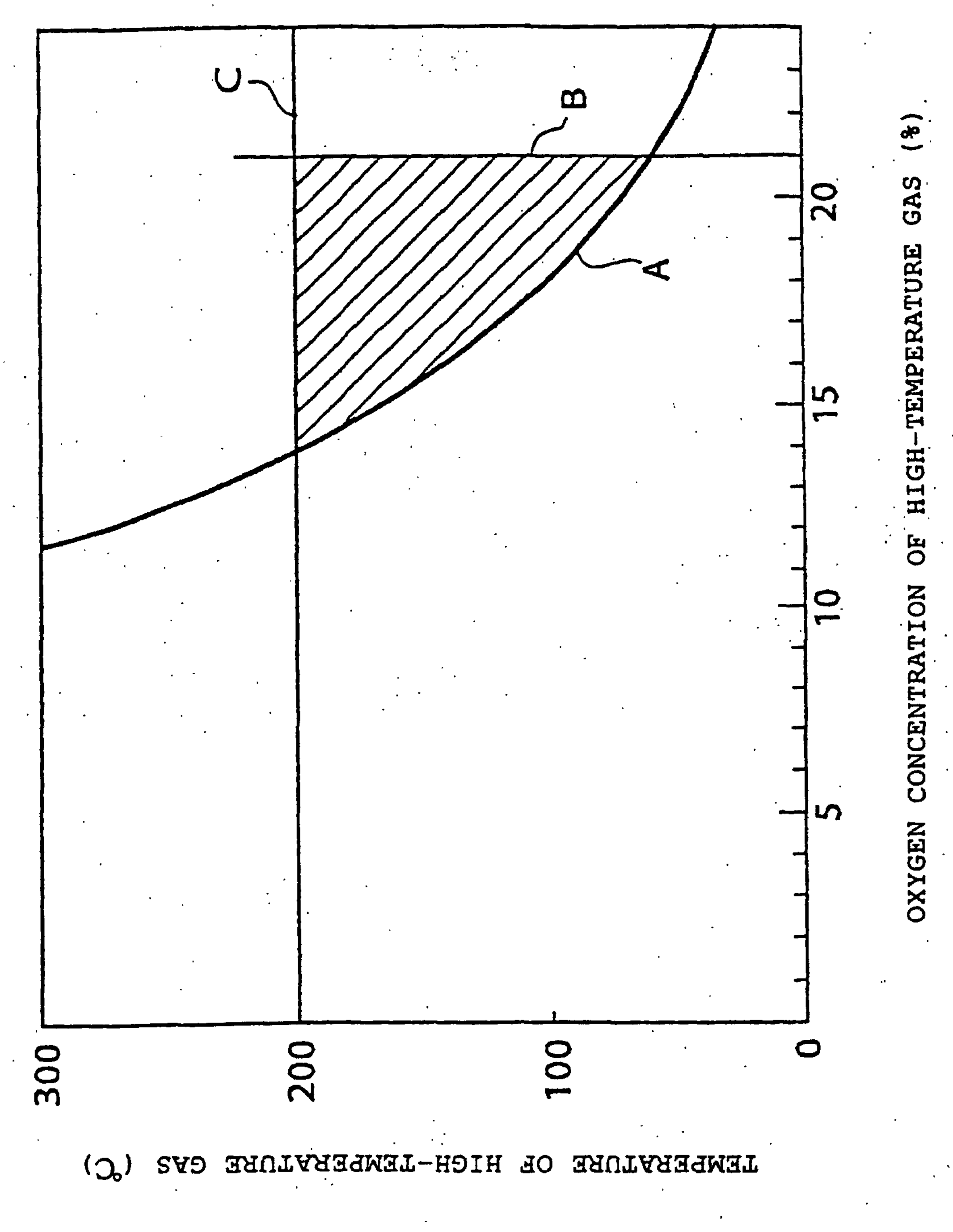
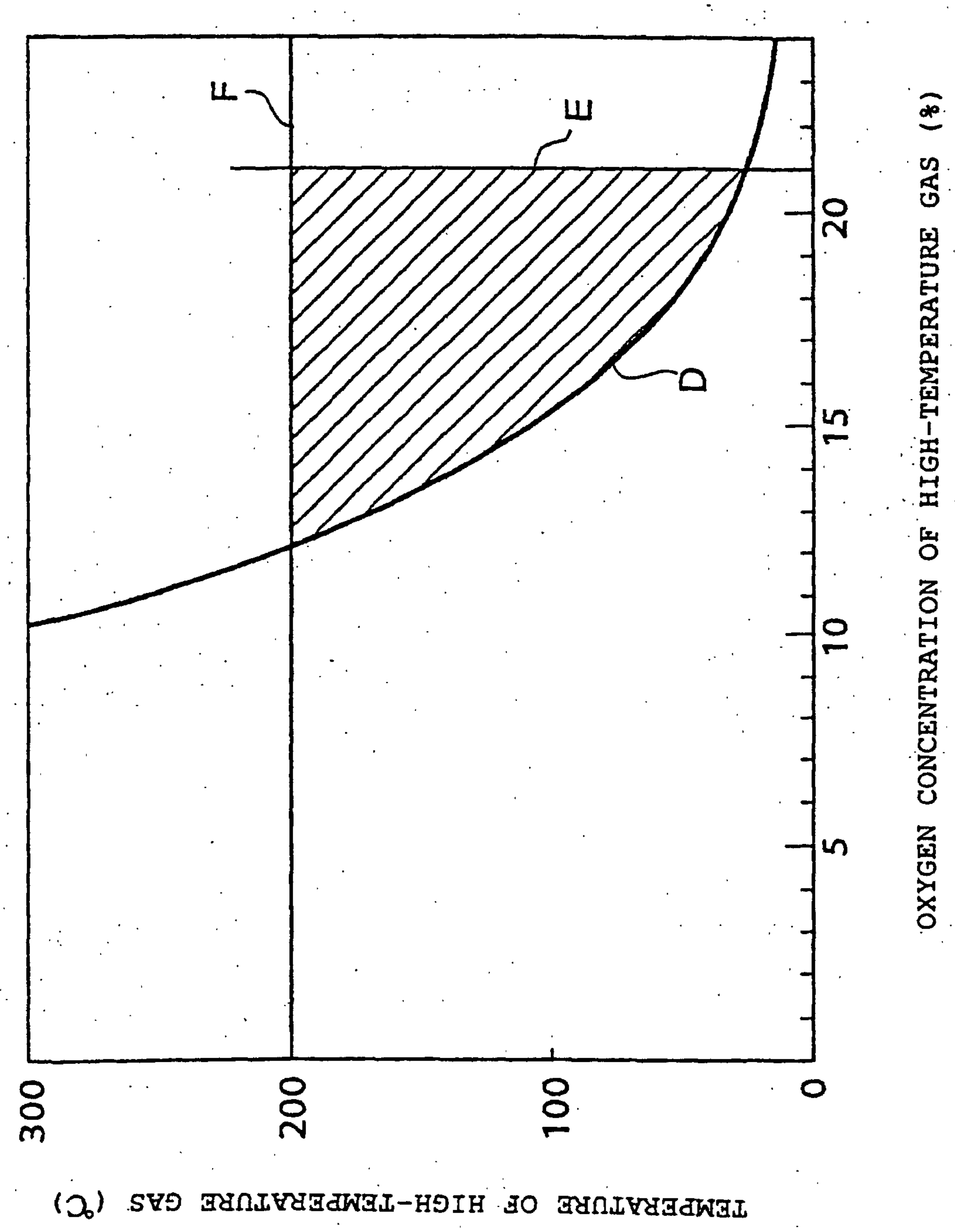

TEMPERATURE OF HIGH-TEMPERATURE GAS (°C)
300
200
100
0
5
10
15
20
OXYGEN CONCENTRATION OF HIGH-TEMPERATURE GAS (%)
A
B
C

FIG. 9


300
200
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5
10
15
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D
E
F
OXYGEN CONCENTRATION OF HIGH-TEMPERATURE GAS (%)
TEMPERATURE OF HIGH-TEMPERATURE GAS (℃)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP03/02623

A. CLASSIFICATION OF SUBJECT MATTER
Int.Cl[7] F23G5/50, F23G5/00, F23G5/44, F23G5/30

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[7] F23G5/50, F23G5/00, F23G5/44, F23G5/30

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

Jitsuyo Shinan Koho	1926-1996	Toroku Jitsuyo Shinan Koho	1994-2003
Kokai Jitsuyo Shinan Koho	1971-2003	Jitsuyo Shinan Toroku Koho	1996-2003

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 2002-228130 A (Mitsubishi Heavy Industries, Ltd.), 14 August, 2002 (14.08.02), Full text; Fig. 2 (Family: none)	1-3,6,8-11 4,5,7,12
X Y	CD-ROM of the specification and drawings annexed to the request of Japanese Utility Model Application No. 65008/1991 (Laid-open No. 17311/1993) (Ishikawajima-Harima Heavy Industries Co., Ltd.), 05 March, 1993 (05.03.93), Full text; Fig. 1 (Family: none)	1-3,6,8-10 4,5
X Y	EP 0413104 A1 (EBARA CORP.), 20 February, 1991 (20.02.91), Full text; Figs. 1 to 4 & US 5044287 A & JP 3-17416 A	15,16 2,3,5-7,9,10

[X] Further documents are listed in the continuation of Box C. [ ] See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier document but published on or after the international filing date
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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
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
04 June, 2003 (04.06.03)	17 June, 2003 (17.06.03)
Name and mailing address of the ISA/ Japanese Patent Office	Authorized officer
Facsimile No.	Telephone No.

Form PCT/ISA/210 (second sheet) (July 1998)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP03/02623

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 2001-241629 A (Mitsubishi Heavy Industries, Ltd.), 07 September, 2001 (07.09.01), Full text; Fig. 1 (Family: none)	11-14
X	JP 4-273910 A (Kobe Steel, Ltd.), 30 September, 1992 (30.09.92), Full text; Figs. 1, 4 (Family: none)	13,14

Form PCT/ISA/210 (continuation of second sheet) (July 1998)