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

(11) EP 0 601 584 B1

(12) **EUROPEAN PATENT SPECIFICATION**

(45) Date of publication and mention of the grant of the patent:
27.08.1997 Bulletin 1997/35

(51) Int Cl.6: **F23G 5/14**, F23G 5/50, F23L 9/02, F23G 5/30

(21) Application number: **93119892.3**

(22) Date of filing: **09.12.1993**

(54) Waste incinerator and waste incinerating method using same

Anlage und Verfahren zur Abfallverbrennung

Dispositif et procédé d'incinération de déchets

(84) Designated Contracting States:
DE FR GB IT

(30) Priority: **30.07.1993 JP 189946/93**
11.12.1992 JP 331973/92

(43) Date of publication of application:
15.06.1994 Bulletin 1994/24

(73) Proprietor: **KABUSHIKI KAISHA KOBE SEIKO SHO**
Kobe 651 (JP)

(72) Inventors:
- **Takahashi, Kazuo, c/o Kobe Steel, Ltd. Kobe-shi, Hyogo, 651 (JP)**
- **Kawabata, Hiroaki, c/o Kobe Steel, Ltd. Kobe-shi, Hyogo, 651 (JP)**
- **Suyari, Mamoru, c/o Kobe Steel, Ltd. Kobe-shi, Hyogo, 651 (JP)**
- **Ito, Tadashi, c/o Kobe Steel, Ltd. Kobe-shi, Hyogo, 651 (JP)**

(74) Representative: **Pellmann, Hans-Bernd, Dipl.-Ing.**
Patentanwaltsbüro
Tiedtke-Bühling-Kinne & Partner
Bavariaring 4
80336 München (DE)

(56) References cited:
EP-A- 0 033 356
EP-A- 0 289 932
EP-A- 0 359 544
EP-A- 0 458 967
US-A- 4 300 460

- **PATENT ABSTRACTS OF JAPAN vol. 17, no. 191 (M-1396)14 April 1993 & JP-A-04 340 014 (NAKANISHI TORU) 26 November 1992**
- **PATENT ABSTRACTS OF JAPAN vol. 15, no. 8 (M-1067)9 January 1991 & JP-A-02 259 325 (BABU HITACHI ENG SERVICE KK) 22 October 1990**

EP 0 601 584 B1

Description

The present invention relates to a waste incinerator according to the preamble of claim 1 adapted to be installed in a waste incinerating plant or the like, and also relates to a waste incinerating method using the waste incinerator according to the preamble of claim 7.

In general, an incinerator constitutes one of important equipments in a waste incinerating plant, and serves to completely burn and incinerate refuse supplied and also to suppress the generation of harmful substances during combustion of the refuse.

Such an incinerator is generally classified into a stoker type and a fluidized bed type. An example of the structure of the fluidized bed type incinerator in the prior art is shown in Fig. 9.

Referring to Fig. 9, an incinerator body 80 has a laminated structure consisting of a refractory 81, an insulator 82, and a shell 83, which are laminated in this order from the inside of the body 80. Further, a sand bed 84 is provided at the bottom in the body 80. A fluidizing air (primary air for combustion) is injected into the sand bed 84 through fluidizing grids 86 provided under the sand bed 84, thus starting fluidization of the sand bed 84. At starting, the sand bed 84 is heated by a temperature raising burner 87. When the temperature of the sand bed 84 reaches about 700°C, refuse is supplied from a refuse feeder 88 into the incinerator, whereby a part of the refuse is fired and gasified by the heat of the sand bed 84. The heat generated by the combustion of the refuse is partially taken into the sand bed 84 to maintain the temperature of the sand bed 84 at a steady temperature of about 700°C. The gasified refuse enters a space (free board) 90 defined above the sand bed 84. In the free board 90, the gasified refuse is mixed with a secondary air (auxiliary combustion air) supplied from a secondary combustion air nozzle 89, thus performing secondary combustion. Then, the combustion gas generated in the free board 90 is ejected from the incinerator at an outlet temperature of about 900°C. On the other hand, the remaining incombustible is circulated in the sand bed 84, and is finally ejected from the incinerator through an incombustible extraction pipe 92, an incombustible extractor 94, and a vibrating screen 96. The sand (fluidic medium) separated from the incombustible by the vibrating screen 96 is returned through a fluidic medium circulator 98 to the sand bed 94 in the incinerator.

Further, reference numeral 99 denotes a fuel supply hole for supplying an auxiliary fuel into the sand bed 84.

In recent years, the emission of dioxin from the waste incinerating plant constitutes a serious social problem. In regulating the emission of dioxin, it is known that three Ts, namely, (1) a residence time (T) of the gas in the free board 90, (2) a temperature (T) of the gas in the free board 90, and (3) a turbulence (T) of the gas in the free board 90, i.e., an efficiency of mixing between the gasified refuse and the air, are important.

In the conventional incinerator, the conditions on the time and the temperature of the above three Ts are enough met, but the improvement of the mixing efficiency is a great subject to be considered. In order to improve the efficiency of mixing between the gasified refuse (unburned gas) and the air, there have been proposed various means such as (A) means for horizontally blowing a secondary air into the incinerator to bend a main gas flow, and (B) means for changing the shape of the incinerator by constriction or bend to thereby induce the turbulence of the gas. However, none of these means can provide a satisfactory effect.

As another way rather than the improvement of the mixing efficiency, combustion control may be carried out so as to supply an optimum air quantity for an actual supply quantity of refuse. Although such a combustion control can reduce the emission of dioxin, it is difficult to accurately measure the actual supply quantity of refuse. Further, a combustion condition varies with a quality of refuse. Accordingly, it is actually difficult to carry out the accurate combustion control as mentioned above.

From the JP-A-4340014 a method is known for mixing and stirring combustion gas and secondary air surely by supplying secondary air which mixes steam in a secondary combustion chamber of an incinerator. The seoncdary air volume can be increasied or decreasied the based on the combustion gas volume that is measured in the secondary combustion chamber. At the same time, the volume of decrease is compensated with a steam volume.

Furthermore, from the EP-A-0 458 967 a waste incinerator is known which comprises a first combustion zone for burning said waste to be gasified and a second combustion zone arranged above said primary combustion zone in said incinerator for further burning gas generated in said primary combustion zone. The second combustion zone is formed such that the inlet portion of the second combustion zone has a diameter which increases upwardly. Furthermore, there are provided air supplying means for supplying an auxiliary combustion air into said incinerator.

The object of the present invention is to improve a waste incinerator and a waste incinerating method so that an effective mix of gasified waste with an auxiliary combustion air can be achieved while the emission of dioxin can be reduced.

This object is achieved by a waste incinerator comprising the features according to claim 1 and by a waste incinerating method comprising the steps of claim 7.

Futher improvements of the present invention are the subject-matter of the dependent claims.

(Operation)

In the waste incinerator according to the present invention waste is burned to generate gas in the primary combustion zone, and the gas is then introduced into the secondary combustion zone, in which the gas is further burned. Further, a recirculation vortex of gas directed upwardly from the inlet portion of the secondary combustion zone and turned down before the outlet portion of the secondary combustion zone is formed in the secondary combustion zone. Accordingly, the gas and the auxiliary combustion air can be sufficiently mixed with each other by this recirculation vortex.

In the waste incinerator according to the present invention, the auxiliary combustion air supplied to the inlet portion of the secondary combustion zone and the unburned gas generated by the combustion of waste in the primary combustion zone are introduced into the secondary combustion zone. Then, the mixture of the gas and the air is raised toward the outlet portion of the secondary combustion zone, and is then turned down by the restriction formed at the outlet portion of the secondary combustion zone. Then, the mixture thus turned down is forced downwardly by the auxiliary combustion air supplied downwardly at the outlet portion of the secondary combustion zone, thus forming the recirculation vortex.

In the waste incinerator according to claim 2, the auxiliary combustion air supplied at the inlet portion of the secondary combustion zone is swirled to thereby accelerate the formation of the recirculation vortex. In the waste incinerator according to claim 8, the gas passage at the inlet portion of the secondary combustion zone is rapidly increased in diameter, so that the rising gas passing through the inlet portion is expanded in the radial direction of the inlet portion to flow into the secondary combustion zone. Further, the auxiliary combustion air is supplied downwardly at the outlet portion of the secondary combustion zone, thereby more stably accelerating the formation of the recirculation vortex.

In the case where carbon or soot is generated in the combustion gas, or in the case where an oxygen quantity or a fuel supply quantity is small, complete combustion in the incinerator cannot be expected in spite of good mixing in the secondary combustion zone if the residence time of the combustion gas in the incinerator is insufficient. In view of this, the waste incinerator according to claim 4 is provided with a tertiary combustion zone between the secondary combustion zone and the outlet of the incinerator. Accordingly, the combustion gas generated in the secondary combustion zone is retained in the tertiary combustion zone until the gas is ejected from the outlet of the incinerator. Thus, more complete combustion can be effected.

In the waste incinerator according to claim 3 or 5, the cooling fluid is fed to the cooling jacket formed in the side wall of the incinerator surrounding the secondary combustion zone or the tertiary combustion zone, thereby preventing an abnormal increase in temperature in the incinerator and simultaneously recovering the heat generated in the incinerator through the cooling fluid to effectively utilize thermal energy.

In the waste incinerator according to claim 6, the flow rate of the cooling fluid is controlled according to an actual temperature in the incinerator, thereby maintaining a proper temperature in the incinerator more accurately.

In the incinerating method according to claim 8, steam or atomized water larger in specific gravity than the auxiliary combustion air is mixed with the auxiliary combustion air, thereby increasing the kinetic energy of the water-containing auxiliary combustion air by an increase in mass of water. Accordingly, a force of the auxiliary combustion air penetrating through the flow of the rising gas to reach the center of the incinerator (which force will be hereinafter referred to as a penetration force) can be increased to thereby effect the formation of a stronger recirculation vortex and the adjustment of a vorticity.

(Effect)

As described above, according to the present invention, the recirculation vortex is formed in the secondary combustion zone to improve the efficiency of mixing between the auxiliary combustion air and the gasified waste. Accordingly, the emission of dioxin can be greatly suppressed without complex combustion control.

In particular, in the waste incinerator according to claim 2, the auxiliary combustion air is injected in a swirling condition from the inlet portion of the secondary combustion zone. Accordingly, the recirculation vortex can be formed more easily.

In the waste incinerator according to the present invention, the outlet portion of the secondary combustion zone is configured so that the gas passage at the outlet portion is gradually restricted toward the upper end of the outlet portion. Accordingly, the auxiliary combustion air supplied downwardly from the outlet portion of the secondary combustion zone can be prevented from flowing into the primary combustion zone owing to the acceleration of formation of the recirculation vortex by the rapid expansion of the gas passage at the inlet portion of the secondary combustion zone and owing to the specific shape of the secondary combustion zone. As a result, the recirculation vortex can be stabilized.

In the waste incinerator according to claim 4, the gas burned in the secondary combustion zone is retained in the tertiary combustion zone until the gas reached the outlet of the incinerator. Accordingly, even in the case where the gas burned in the secondary combustion zone contains a substance requiring a long time for combustion, such as carbon, or in the case where an oxygen quantity or a fuel supply quantity is small, sufficient combustion in the incinerator can be ensured.

In the waste incinerator according to claim 3 or 5, the cooling fluid is fed to the cooling jacket formed in the side wall of the incinerator surrounding the secondary combustion zone or the tertiary combustion zone. Accordingly, an excessive increase in temperature in the incinerator can be prevented to ensure normal combustion. Moreover, the heat generated in the incinerator can be recovered through the cooling fluid as a medium, thereby realizing energy saving.

In the waste incinerator according to claim 9, the flow rate of the cooling fluid is controlled according to an actual temperature in the incinerator, thereby maintaining a proper temperature range in the incinerator more accurately.

In the incinerating method according to claim 8, steam or atomized water larger in specific gravity than the auxiliary combustion air is mixed with the auxiliary combustion air, thereby increasing the kinetic energy of the air/water mixture by an increase in mass of water. Accordingly, the penetration force of the auxiliary combustion air (i.e., the force of the auxiliary combustion air penetrating through the flow of the rising gas to reach the center of the incinerator) can be increased to thereby effect the formation of a stronger recirculation vortex and the adjustment of a vorticity.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is an elevational view in section of an essential part of a waste incinerator according to the present invention;

Figs. 2(a) and 2(b) are cross sections taken along the line A-A and the line B-B in Fig. 1, respectively;

Fig. 3 is a view illustrating the result of computation of a CO mixed condition and a gas velocity vector in a conventional waste incinerator;

Fig. 4 is a view illustrating the result of computation of a CO mixed condition and a gas velocity vector in the waste incinerator of the first preferred embodiment;

Fig. 5 is an elevational view in section of an essential part of a waste incinerator in a second preferred embodiment of the present invention;

Fig. 6 is an elevational view in section of an essential part of a waste incinerator in a third preferred embodiment of the present invention;

Fig. 7 is an elevational view in section of an essential part of a waste incinerator in a fourth preferred embodiment of the present invention;

Figs. 8(a) and 8(b) are horizontal sectional views similar to Figs. 2(a) and 2(b), respectively, showing a modification of the horizontal sectional shape of the waste incinerator according to the present invention;

Fig. 9 is an elevational view in section of a waste incinerator in the prior art;

Fig. 10 is a graph showing a test result on combustibility in model incinerators of the prior art type and the present invention type; and

Fig. 11 is an elevational view in section showing a modification of the internal shape of the waste incinerator according to the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

A first preferred embodiment of the present invention will now be described with reference to Figs. 1 to 4. In the waste incinerator shown in Figs. 1 to 4, the laminated structure of the side wall of an incinerator body 10 and the construction of the peripheral equipment are similar to those shown in Fig. 9, and the explanation thereof will be omitted herein.

As shown in Fig. 1, the inside of the incinerator body 10 is divided into a primary combustion zone (gasification zone) A1, a secondary combustion zone (main combustion zone) A2, and a tertiary combustion zone A3, which are arranged in this order from the lower side. A lower restriction 12 projecting from the inner wall surface of the body 10 is provided at an interfacial portion between the primary combustion zone A1 and the secondary combustion zone A2, and an upper restriction 14 projecting from the inner wall surface of the body 10 is provided at an interfacial portion between the secondary combustion zone A2 and the tertiary combustion zone A3. An air supplying device (air supplying means) 15 is connected to the lower restriction 12 and the upper restriction 14.

The lower restriction 12 has an inner circumferential surface consisting of a tapering surface 16 upwardly decreasing in diameter, a cylindrical surface 17 constant in diameter, and a tapering surface 18 upwardly increasing in diameter, which are arranged in this order from the lower side. As shown in Fig. 2(a), the cylindrical surface 17 is formed with a plurality of secondary air injection holes 20 arranged circumferentially at regular intervals so that the air supplied from the air supplying device 15 may be injected as a secondary air (auxiliary combustion air) from each secondary air injection hole 20 into the incinerator. The direction of injection of the secondary air is so set as to be inclined upwardly at an appropriate angle (e.g., about 30°) with respect to a horizontal direction in a vertical section as shown in Fig. 1 and to be inclined with the same orientation at an appropriate angle (e.g., about 45°) with respect to a radial direction in a horizontal section as shown in Fig. 2(a). In other words, the direction is set so that the secondary air may be supplied upwardly spirally into the incinerator.

The upper restriction 14 has an inner circumferential surface consisting of a tapering surface 22 upwardly decreasing in diameter and a tapering surface 24 upwardly increasing in diameter, which are arranged in this order from the lower side. As shown in Fig. 2(b), the upper restriction 14 is formed with a plurality of (e.g., four) tertiary air injection holes 26 arranged circumferentially at equal intervals and with a plurality of auxiliary tertiary air injection holes 28 between the tertiary air injection holes 26 so that the air supplied from the air supplying device 15 may be injected as a tertiary air (auxiliary combustion air) from these injection holes 26 and 28 into the incinerator.

The direction of injection of the tertiary air from the tertiary air injection holes 26 is so set as to be inclined downwardly at an appropriate angle with respect to a horizontal direction in a vertical section as shown in Fig. 1 and to coincide with a radial direction in a horizontal section as shown in Fig. 2(b). Concretely, when a penetration force of the tertiary air injected from the tertiary air injection holes 26 is strong (i.e., a force of the tertiary air penetrating through a rising gas flow in the incinerator to reach the center of the incinerator is strong), the direction is set at an appropriate angle ranging from about 0° to about 60° (e.g., about 45°) with respect to the radial direction in a plane perpendicular to a center axis of the incinerator.

Further, the direction of injection of the tertiary air from the auxiliary tertiary air injection holes 28 is so set as to coincide with the horizontal direction in the vertical section as shown in Fig. 1 and coincide with the radial direction in the horizontal section as shown in Fig. 2(b).

Thus, the internal shape of the incinerator in the secondary combustion zone A2 is set so that the inlet portion of the zone A2 is upwardly increased in diameter and the outlet portion of the zone A2 is upwardly decreased in diameter.

In such an incinerator, refuse is supplied onto a sand bed (not shown) provided in the primary combustion zone A1, and the refuse is then burned to be gasified, which is in turn introduced into the secondary combustion zone A2.

In the secondary combustion zone A2, the secondary air is upwardly injected in a swirling condition from the secondary air injection holes 20 of the lower restriction 12 forming the inlet portion of the zone A2. The secondary air injected is raised as radially expanding, and is thereafter restricted toward the center axis by the tapering surface 22 of the upper restriction 14 forming the outlet portion of the zone A2. Further, the tertiary air is downwardly injected from the tertiary air injection holes 26 of the upper restriction 14, thereby forming a recirculation vortex (i.e., a gas flow turning down at the outlet portion of the zone A2 after rising) in combination with the secondary air. Owing to this recirculation vortex, the secondary air and the tertiary air are effectively mixed with the combustion gas rising from the primary combustion zone A1, thereby effectively reburn the combustion gas. A gas generated by this recombustion is allowed to flow through the tertiary combustion zone A3, and is then ejected from the upper portion of the incinerator.

As mentioned above, the lower and upper restrictions 12 and 14 are provided at the inlet and the outlet of the secondary combustion zone A2, respectively, and the secondary air and the tertiary air are injected from the lower and upper restrictions 12 and 14, respectively, thereby forming the recirculation vortex in the secondary combustion zone A2. Accordingly, the gasified refuse is sufficiently mixed with the secondary air and the tertiary air (both serving as the auxiliary combustion air) by utilizing this recirculation vortex. As a result, the generation of dioxin can be greatly suppressed.

In particular, since the secondary air is introduced in the swirling condition in this preferred embodiment, the formation of the recirculation vortex is effected more easily, and the flow in the secondary combustion zone A2 becomes complex to thereby more accelerate the mixing of the combustion gas with the air in the zone A2. Further, since the flow in the tertiary combustion zone A3 also becomes a swirling condition, a residence time in the zone A3 can be lengthened.

Further, since the tertiary air is injected downwardly from the tertiary air injection holes 26 in this preferred embodiment, the gas in the secondary combustion zone A2 can be prevented from upwardly passing along the center axis of the incinerator, thereby forming a stronger recirculation vortex. Further, since the tertiary air is injected also from the auxiliary tertiary air injection holes 28 located between the tertiary air injection holes 26, the upward pass of the gas along the center axis can be prevented more reliably.

In this preferred embodiment, both the restriction of the gas passage by the tapering surface 22 and the downward injection of the tertiary air at the outlet of the secondary combustion zone A2 are particularly important for the formation of the recirculation vortex. If the restriction of the gas passage by the tapering surface 22 were not present, the formation of the vortex would not be accelerated. Furthermore, if the downward injection of the tertiary air were not present, the gas containing an intermediate product generated in the primary combustion zone A1 would upwardly pass through the central portion of the incinerator to result in insufficient mixing.

Figs. 3 and 4 show the results of numerical calculations of a CO mixed condition and a gas velocity vector in the conventional incinerator shown in Fig. 9 and in the incinerator of the preferred embodiment shown in Fig. 1, respectively. It is understood from Figs. 3 and 4 that almost no recirculation vortex is formed in the conventional incinerator to result in a bad mixed condition of CO, whereas the recirculation vortex is apparently formed in the secondary combustion zone A2 of the incinerator in this preferred embodiment, and CO is sufficiently mixed with the secondary air and the tertiary air by this recirculation vortex.

Fig. 10 shows the results of a combustion test in two model furnaces of the conventional type and the preferred embodiment type each having a capacity of 2.5 tons per day. In each model furnace, no sand bed is provided, and a city gas burner is used. However, simulation is performed so that a CO exhaust quantity and its timed pattern in a combustion operation under the same conditions as those in an actual furnace having a sand bed (i.e., a waste incinerator with a fluidized bed) can be obtained. More specifically, a combustion operating method such that a CO exhaust quantity and its timed pattern similar to those in the conventional actual furnace are generated is searched by using the model furnace of the conventional type. Thereafter, combustion operation is carried out in the model furnace of the preferred embodiment type by the same method as the combustion operating method searched above to measure the result.

In Fig. 10, "rated conditions" means design conditions, and accordingly the CO exhaust quantities under the rated conditions in both types are zero. On the other hand, "local low-load conditions" means operating conditions in the condition where the supply of refuse is cut, and "local overload conditions" means operating conditions in the condition where refuse is supplied locally excessively.

As shown in Fig. 10, it is understood that the CO exhaust quantity can be suppressed to 1% or less under the local overload conditions by the model furnace of the preferred embodiment type as compared with by the model furnace of the conventional type, and that the CO exhaust quantity can be suppressed to substantially zero under the local low-load conditions. This result is considered to be due to the fact that the unburned gas is well mixed with the auxiliary combustion air by the recirculation vortex formed in the secondary combustion zone of the model furnace of the preferred embodiment type.

Next, a second preferred embodiment of the present invention will be described with reference to Fig. 5.

In the incinerator of the first preferred embodiment, the more rapidly the gas passage is expanded by the upper tapering surface 18 of the lower restriction 12, the more easily the recirculation vortex is formed. However, in association with this, a degree of restriction by the tapering surface 16 becomes higher to cause an excessive increase in velocity of the main gas flow with the result that the formation of the vortex becomes difficult.

In view of this, the incinerator of the second preferred embodiment is designed so that the incinerator body 10 itself is formed with a divergent portion 30 and a convergent portion 32 at the inlet and the outlet of the secondary combustion zone A2, respectively. Accordingly, the inner diameter of the incinerator in the secondary combustion zone A2 is actually larger than that in the other zones A1 and A3. According to such a structure, the gas passage can be rapidly expanded at the inlet of the secondary combustion zone A2 without restricting the outlet of the primary combustion zone A1, thereby easily forming a sufficient recirculation vortex.

Next, a third preferred embodiment of the present invention will be described with reference to Fig. 6.

In the third preferred embodiment, a center axis G1 of the incinerator in the primary combustion zone A1 is horizontally shifted from a center axis G2 of the incinerator in the secondary combustion zone A2, thereby forming an opening through the upper surface of a housing defining the primary combustion zone A1 and using this opening as a refuse supply hole 34.

According to such a structure, the refuse supply hole 34 can be located nearer to the central portion of the primary combustion zone A1 as compared with the structure that the center axis G1 in the primary combustion zone A1 is coincident with the center axis G2 in the secondary combustion zone A2 as shown in the first and second preferred embodiments. Further, also in the third preferred embodiment wherein the primary combustion zone A1 and the secondary combustion zone A2 are eccentric from each other, a recirculation vortex can be stably formed in the secondary combustion zone A2, thereby effecting sufficient mixing of the combustion gas and the auxiliary combustion air and a reduction in dioxin.

Next, a fourth preferred embodiment of the present invention will be described with reference to Fig. 7.

The fluidized bed type incinerator mentioned above in each preferred embodiment is excellent in load following ability (i.e., high in responsiveness of a temperature change in the incinerator due to refuse supply). Therefore, particularly in the secondary combustion zone A2 where positive mixing is performed to promote combustion and in the tertiary combustion zone A3 downstream of the zone A2, the temperature in the incinerator easily exceeds a preferable temperature range (800 - 1000°C in the above preferred embodiments). Such an undue temperature rise may cause the generation of thermal NOx or melting of fly ash on the wall surface of the incinerator, thus reducing the performance of the incinerator. Further, about 2% of a heat quantity generated in the incinerator is wastefully dissipated from the wall of the incinerator to the outside thereof, so that the recovery of such a dissipated heat quantity is desired.

In view of this, the incinerator of the fourth preferred embodiment is designed so that a cooling jacket is provided on the wall of the incinerator to effect cooling of the inside of the incinerator and recovery of heat dissipating from the wall of the incinerator.

More specifically, referring to Fig. 7, cooling jackets 36 and 38 each having a doughnut-shaped space therein are formed in the side walls surrounding the secondary combustion zone A2 and the tertiary combustion zone A3, respectively. Both the cooling jackets 36 and 38 are connected through a cooling water supply passage 39 to a pump (feeding means) 40, and are connected through a hot water recovery passage 42 to a tank (not shown).

The incinerator body is provided with thermocouples (temperature detecting means) 44 and 46 for detecting temperatures in the secondary combustion zone A2 and the tertiary combustion zone A3, respectively, and is also provided with a flow control device 48 for controlling a discharge quantity from the pump 40 according to detected temperatures by the thermocouples 44 and 46. The flow control device 48 is so designed as to increase the discharge quantity from the pump 40 from a fundamental flow rate when at least one of the detected temperatures by the thermocouples 44 and 46 exceeds a permissible maximum temperature (1000°C in this preferred embodiment).

According to such a construction, the temperature in the incinerator can be maintained at a proper temperature by the cooling water flowing in the cooling jackets 36 and 38, and the heat generated in the incinerator can be recovered through the cooling water as a medium (concretely, a hot water obtained by the heat generated in the incinerator is recovered to the tank). Accordingly, the heat of the hot water can be recycled for heating or the like in an incinerating plant. Concretely, it has been confirmed that a hot water having a temperature of about 80°C can be recovered at a rate of 2.5 tons per hour in an incinerator having a refuse disposal capacity of 100 tons per day owing to the provision of the cooling jackets 36 and 38.

In this preferred embodiment, the following modifications may be made.

(a) Only one of the cooling jackets 36 and 38 may be provided for the secondary combustion zone A2 or the tertiary combustion zone A3. In particular, when the cooling jacket 38 is provided for the tertiary combustion zone A3, the temperature of a combustion gas to be exhausted from an exhaust outlet 50 can be more reliably suppressed to a prescribed temperature or less.

(b) While the common pump 40 is connected to both the cooling jackets 36 and 38 in Fig. 7, two pumps may be individually connected to the cooling jackets 36 and 38, and the discharge quantities of the two pumps may be individually controlled according to the detected temperatures in the zones A2 and A3.

(c) The cooling fluid flowing in the cooling jackets 36 and 38 is not limited to water. For example, air may be fed to the cooling jackets 36 and 38, and a hot air obtained by the heat generated in the incinerator may be used as the secondary air and the tertiary air.

Further, in the present invention the following modifications may be made.

(1) The air ratio (or excess air factor) of the gas flowing into the secondary combustion zone A2 may be suitably set in the present invention. However, it is desirable to hold this air ratio to about 1.7 in order not to reduce a combustion temperature. Further, it is greatly desirable to set an air supply direction and momentum so as to form a stable recirculation vortex.

Further, steam or atomized water larger in specific gravity than air may be mixed with the secondary air and the tertiary air to be injected into the incinerator. In this case, the kinetic energy of the air-water mixture can be increased by an increase in mass of water without increasing an injection velocity. Accordingly, the penetration force of the secondary air and the tertiary air can be increased. That is, the force of the secondary air and the tertiary air penetrating the flow of the rising gas to reach the center of the incinerator can be increased.

(2) The air ratio in the secondary combustion zone A2 may also be suitably set in the present invention. However, it is preferable to adjust the air ratio so that high temperatures of about 1000°C can be maintained in this zone A2. Further, it is greatly preferable to decide the momentum of the air so that the recirculation vortex is formed in the above adjusted range of the air ratio.

(3) In the present invention, a specific temperature of the auxiliary combustion air is not limited. However, the auxiliary combustion air may be preheated before introduced into the incinerator. In this case, a decrease in combustion temperature due to the introduction of the auxiliary combustion air unless preheated can be avoided to thereby ensure better combustion.

(4) It is sufficient in the present invention that the auxiliary combustion air having a penetration force is to be downwardly supplied at the outlet of the secondary combustion zone A2, and the tertiary combustion zone A3 may be therefore be omitted. However, the provision of the tertiary combustion zone A3 can provide an advantage such that the gas burned in the secondary combustion zone A2 can be retained in the incinerator for a longer period of time, thereby well performing the combustion that is not enough only by the acceleration of mixing. For example, even in the case where a substance requiring a long time for combustion, such as carbon or soot is generated in the combustion gas, or in the case where an oxygen quantity or a fuel supply quantity is small, complete combustion can be performed by letting the gas burned in the secondary combustion zone A2 reside in the tertiary combustion zone A3 for a given period of time or more.

(5) In the present invention, the horizontal sectional shape of the incinerator is not limited to a circular shape as in the above preferred embodiments. For example, the horizontal sections taken along the lines A-A and B-B in Fig. 1 may be rectangular as shown in Figs. 8(a) and 8(b), respectively. Also in this case, a recirculation vortex similar to that in the above preferred embodiments can be formed by expanding and contracting the gas passage at the inlet and the outlet of the secondary combustion zone A2, respectively, and by properly introducing the auxiliary combustion air. Further, as shown in Fig. 8(a), the direction of injection of the secondary air may be inclined in the horizontal plane. In this case, the secondary air can be supplied in a swirling condition.

(6) In the present invention, the direction of the re-

circulation vortex is not especially limited. For example, in the case where the free board in the incinerator has a rectangular horizontal section as shown in Figs. 8(a) and 8(b), an air supplying structure 21 may be provided in the free board as shown in Fig. 11. The air supplying structure 21 extends in a direction perpendicular to the plane of the sheet of Fig. 11 so as to penetrate a pair of opposed side walls of the incinerator. The lover surface of the structure 21 functions as the tapering surface 22 for restricting the gas passage. The tertiary air injection holes 26 and the auxiliary tertiary air injection holes 28 are formed at both ends of the structure 21, so as to supply the auxiliary combustion air similarly to the first preferred embodiment. With this arrangement, the direction of the recirculation vortex can be made reverse to that of the recirculation vortex shown in Fig. 1.

Claims

1. A waste incinerator for burning waste supplied into an incinerator comprising

    a primary combustion zone (A1) for gasifying and burning said waste,
    a secondary combustion zone (A2) arranged above said primary combustion zone (A1) in said incinerator comprising

        a lower restriction (12) provided at an interfacial portion between said primary and said secondary combustion zones (A1, A2) and forming an inlet portion of said secondary combustion zone (A2) being so configured as to upwardly increase in diameter, and
        an upper restriction (14) provided at an outlet portion of said secondary combustion zone (A2) being so configured as to upwardly decrease in diameter
        air supplying means (15) for supplying an auxiliary combustion air into said incinerator for burning said gasified waste,

    characterized in that

    secondary air is upwardly injected by said air supplying means (15) from secondary air injection holes (20) of said lower restriction (12), and tertiary air is downwardly injected by said air supplying means (15) from tertiary air injection holes (26) of said upper restriction (14), thereby forming a recirculation vortex in combination with said secondary air.

2. A waste incinerator according to claim 1, wherein said supply direction of said auxiliary combustion air to be supplied at said inlet portion of said secondary combustion zone (A2) is set so as to be swirled.

3. A waste incinerator according to claim 1 or 2, wherein a cooling jacket (36) is formed in a side wall of said incinerator surrounding said secondary combustion zone (A2), and wherein a feeding means (40) for feeding a cooling fluid to said cooling jacket (36) is provided.

4. A waste incinerator according to any of the preceding claims, wherein a tertiary combustion zone (A3) for retaining gas burned in said secondary combustion zone (A2) is formed between said secondary combustion zone (A2) and an outlet of said incinerator.

5. A waste incinerator according to claim 4, wherein a cooling jacket (38) is formed in a side wall of said incinerator surrounding said tertiary combustion zone (A3), and wherein a feeding means (40) for feeding a cooling fluid to said cooling jacket (38) is provided.

6. A waste incinerator according to claim 3 or 5, wherein temperature detecting means (44, 46) for detecting a temperature in said incinerator and flow control means (48) for controlling a flow rate of said cooling fluid fed to said cooling jackets (36, 38) by said feeding means (40) according to said temperature detected by said temperature detecting means (44, 46) are provided.

7. A waste incinerating method by means of a waste incinerator according to any of the preceding claims comprising the following steps:

    burning said waste in said primary combustion zone (A1),
    further burning said gas generated in said primary combustion zone (A1) in said secondary combustion zone (A2),

    characterized by

    injecting said secondary air upwardly by said air supplying means (15) from secondary air injection holes (20) of said lower restriction (12), and
    injecting said tertiary air downwardly by said air supplying means (15) from tertiary air injection holes (26) of said upper restriction (14), thereby forming a recirculation vortex in combination with said secondary air.

8. A waste incinerating method according to claim 7,

characterized in that
steam or atomized water is mixed with said auxiliary combustion air.

Patentansprüche

1. Ein Müllverbrennungsofen zum Verbrennen von Müll, der in einen Verbrennungsofen zugeführt wird, aufweisend

   eine erste Verbrennungszone (A1) zum Vergasen und Abbrennen dieses Mülles,
   eine zweite Verbrennungszone (A2), die oberhalb der ersten Verbrennungszone (A1) in dem Verbrennungsofen angeordnet ist, aufweisend eine untere Einschnürung (12), die an einem Schnittstellenabschnitt zwischen den ersten und zweiten Verbrennungszonen (A1, A2) vorgesehen ist und einen Einlaßabschnitt der zweiten Verbrennungszone (A2) bildet, der so konfiguriert ist, daß sie nach oben gerichtet im Durchmesser zunimmt, und
   eine obere Einschnürung (14), die an einem Auslaßabschnitt der zweiten Verbrennungszone (A2) vorgesehen ist, die so konfiguriert ist, daß sie nach oben gerichtet im Durchmesser abnimmt,
   eine Luftversorgungsvorrichtung (15) zum Zuführen einer Hilfsverbrennungsluft in den Verbrennungsofen zum Verbrennen des vergasten Mülles,

   dadurch gekennzeichnet, daß

   eine Sekundärluft durch die Luftzuführvorrichtung (15) von Sekundärlufteinblaslöchern (20) der unteren Einschnürung (12) nach oben gerichtet eingeblasen wird, und
   daß Tertiärluft durch die Luftzuführvorrichtung (15) von Tertiärlufteinblaslöchern (26) der oberen Einschnürung (14) nach unten gerichtet eingeblasen wird, wodurch in Verbindung mit der Sekundärluft ein Rückführwirbel gebildet wird.

2. Ein Müllverbrennungsofen gemäß Anspruch 1, wobei die Zuführrichtung der Hilfsverbrennungsluft, die an den Einlaßabschnitt der zweiten Verbrennungszone (A2) geführt werden soll, so eingestellt ist, daß sie verwirbelt wird.

3. Müllverbrennungsofen gemäß Anspruch 1 oder 2, wobei ein Kühlmantel (36) in einer Seitenwand des Verbrennungsofens gebildet ist, der die zweite Verbrennungszone (A2) umgibt, und wobei eine Zuführvorrichtung (40) zum Zuführen einer Kühlflüssigkeit an den Kühlmantel (36) vorgesehen ist.

4. Ein Müllverbrennungsofen gemäß einem der vorhergehenden Ansprüche, wobei eine dritte Verbrennungszone (A3) zum Zurückhalten von Gas, das in der zweiten Verbrennungszone (A2) verbrannt ist, zwischen der zweiten Verbrennungszone (A2) und einem Auslaß des Verbrennungsofens gebildet ist.

5. Ein Müllverbrennungsofen gemäß Anspruch 4, wobei ein Kühlmantel (38) in einer Seitenwand des Verbrennungsofens gebildet ist, der die dritte Verbrennungszone (A3) umgibt, und wobei eine Zuführvorrichtung (40) zum Zuführen einer Kühlflüssigkeit an den Kühlmantel (38) vorgesehen ist.

6. Ein Müllverbrennungsofen gemäß Anspruch 3 oder 5, wobei eine Temperaturerfassungsvorrichtung (44, 46) zum Erfassen einer Temperatur in dem Verbrennungsofen und eine Strömungsregelungsvorrichtung (48) zum Regeln einer Strömungsgeschwindigkeit der Kühlflüssigkeit, die durch die Zuführvorrichtung (40) in Abhängigkeit von der durch die Temperaturerfassungsvorrichtung (44, 46) erfaßten Temperatur an die Kühlmäntel (36, 38) geführt wird, vorgesehen sind.

7. Ein Müllverbrennungsverfahren mittels eines Müllverbrennungsofens gemäß einem der vorhergehenden Ansprüche, die folgenden Schritte aufweisend:

   Verbrennen des Mülls in der ersten Verbrennungszone (A1),
   desweiteren Verbrennen des in der ersten Verbrennungszone (A1) erzeugten Gases in der zweiten Verbrennungszone (A2),

   gekennzeichnet durch

   nach oben gerichtetes Einblasen der Sekundärluft durch die Luftversorgungsvorrichtung (15) von Sekundärlufteinblaslöchern (20) der unteren Einschnürung (12), und
   nach unten gerichtetes Einblasen der Tertiärluft durch die Luftversorgungsvorrichtung (15) von Tertiärlufteinblaslöchern (26) der oberen Einschnürung (14), wodurch in Kombination mit der Sekundärluft ein Rückführwirbel gebildet wird.

8. Ein Müllverbrennungsverfahren gemäß Anspruch 7,
   dadurch gekennzeichnet, daß
   Dampf oder atomisiertes Wasser mit der Hilfsverbrennungsluft vermischt wird.

Revendications

1. Incinérateur de déchets pour brûler des déchets amenés dans un incinérateur comprenant :

   une zone de combustion primaire (A1) pour gazéifier et brûler lesdits déchets,
   une zone de combustion secondaire (A2) agencée au-dessus de ladite zone de combustion primaire (A1) dans ledit incinérateur, comprenant :
   une limitation inférieure (12) disposée au niveau d'une partie formant interface entre lesdites zones de combustion primaire et secondaire (A1, A2) et formant une partie d'entrée de ladite zone de combustion secondaire (A2) conformée de façon à augmenter de diamètre vers le haut, et
   une limitation supérieure (14) disposée au niveau d'une partie de sortie de ladite zone de combustion secondaire (A2) conformée de façon à diminuer de diamètre vers le haut,
   des moyens d'alimentation en air (15) pour amener de l'air de combustion auxiliaire dans ledit incinérateur pour brûler lesdits déchets gazéifiés,

   caractérisé en ce que

   de l'air secondaire est injecté vers le haut par lesdits moyens d'alimentation en air (15) à partir de trous d'injection d'air (20) de ladite limitation inférieure (12), et
   de l'air tertiaire est injecté vers le bas par lesdits moyens d'alimentation en air (15) à partir des trous d'injection d'air tertiaire (26) de ladite limitation supérieure (14), formant de ce fait un tourbillon de recirculation en combinaison avec ledit air secondaire.

2. Incinérateur de déchets selon la revendication 1, dans lequel ledit sens d'alimentation dudit air de combustion auxiliaire à amener au niveau de ladite partie d'entrée de ladite zone de combustion secondaire (A2) est fixé de façon à tourbillonner.

3. Incinérateur de déchets selon la revendication 1 ou 2, dans lequel une enveloppe de refroidissement (36) est formée dans une paroi latérale dudit incinérateur entourant ladite zone de combustion secondaire (A2), et dans lequel des moyens d'amenée (40), pour amener un liquide de refroidissement à ladite enveloppe de refroidissement (36), sont prévus.

4. Incinérateur de déchets selon l'une quelconque des revendications précédentes, dans lequel une zone de combustion tertiaire (A3) pour retenir le gaz brûlé dans ladite zone de combustion secondaire (A2) est formée entre ladite zone de combustion secondaire (A2) et une sortie dudit incinérateur.

5. Incinérateur de déchets selon la revendication 4, dans lequel une enveloppe de refroidissement (38) est formée dans une paroi latérale dudit incinérateur entourant ladite zone de combustion tertiaire (A3), et dans lequel des moyens d'amenée (40), pour amener un liquide de refroidissement à ladite enveloppe de refroidissement (38), sont prévus.

6. Incinérateur de déchets selon la revendication 3 ou 5, dans lequel des moyens de détection de température (44, 46) pour détecter une température dans ledit incinérateur et des moyens de commande d'écoulement (48) pour commander une vitesse d'écoulement dudit liquide de refroidissement amené auxdites enveloppes de refroidissement (36, 38) par lesdits moyens d'amenée (40) selon ladite température détectée par lesdits moyens de détection de température (44, 46), sont prévus.

7. Procédé d'incinération de déchets au moyen d'un incinérateur de déchets selon l'une quelconque des revendications précédentes, comprenant les étapes suivantes :

   la combustion desdits déchets dans ladite zone de combustion primaire (A1),
   la combustion supplémentaire dudit gaz produit dans ladite zone de combustion primaire (A1) dans ladite zone de combustion secondaire (A2),

   caractérisé par

   l'injection dudit air secondaire vers le haut par lesdits moyens d'alimentation en air (15) à partir de trous d'injection d'air (20) de ladite limitation inférieure (12), et
   l'injection dudit air tertiaire vers le bas par lesdits moyens d'alimentation en air (15) à partir des trous d'injection d'air tertiaire (26) de ladite limite supérieure (14), formant de ce fait un tourbillon de recirculation en combinaison avec ledit air secondaire.

8. Procédé d'incinération de déchets selon la revendication 7,
   caractérisé en ce que
   de l'eau vaporisée ou atomisée est mélangée audit air de combustion auxiliaire.

FIG. 1

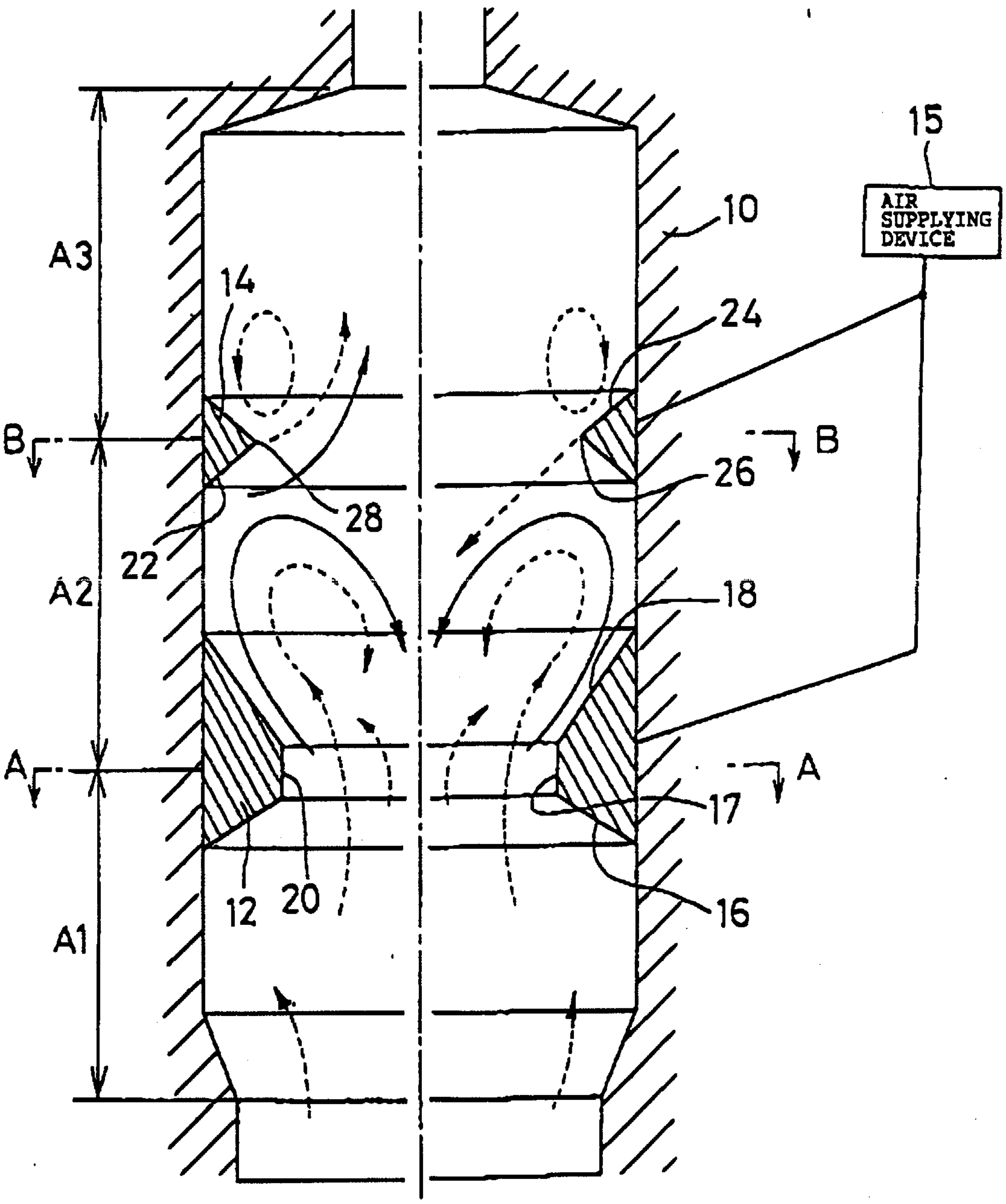

15
AIR SUPPLYING DEVICE
10
A3
14
24
B
B
26
28
22
A2
18
A
A
17
12
20
16
A1

FIG. 2(a)

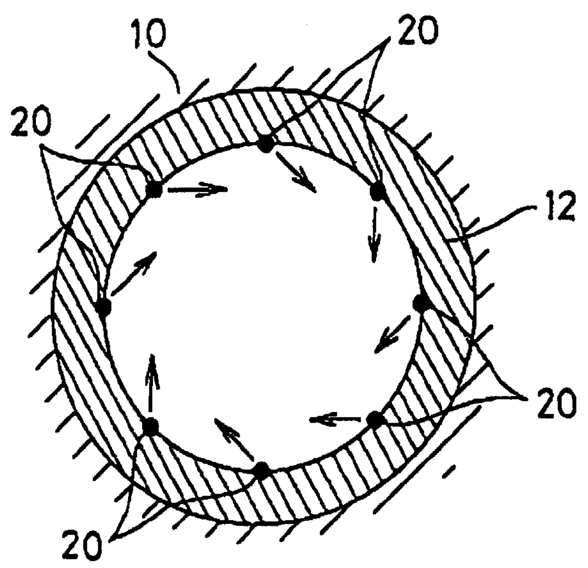


FIG. 2(b)

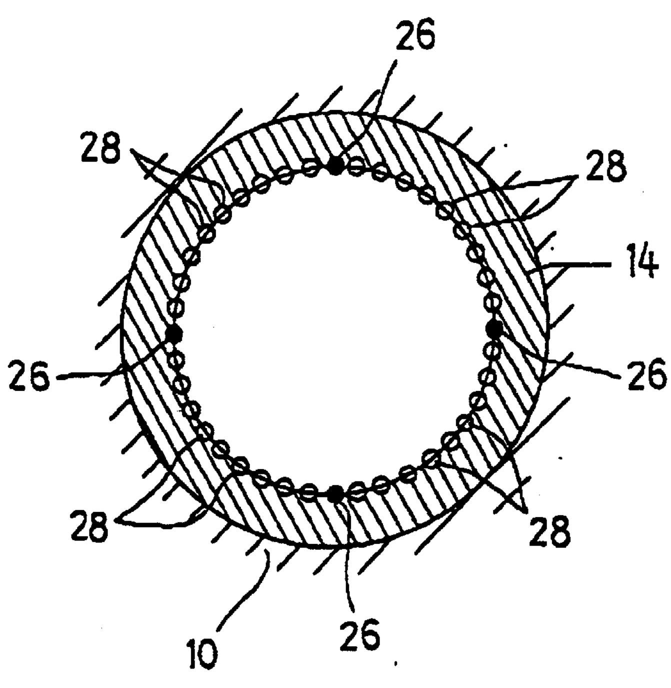


FIG. 3

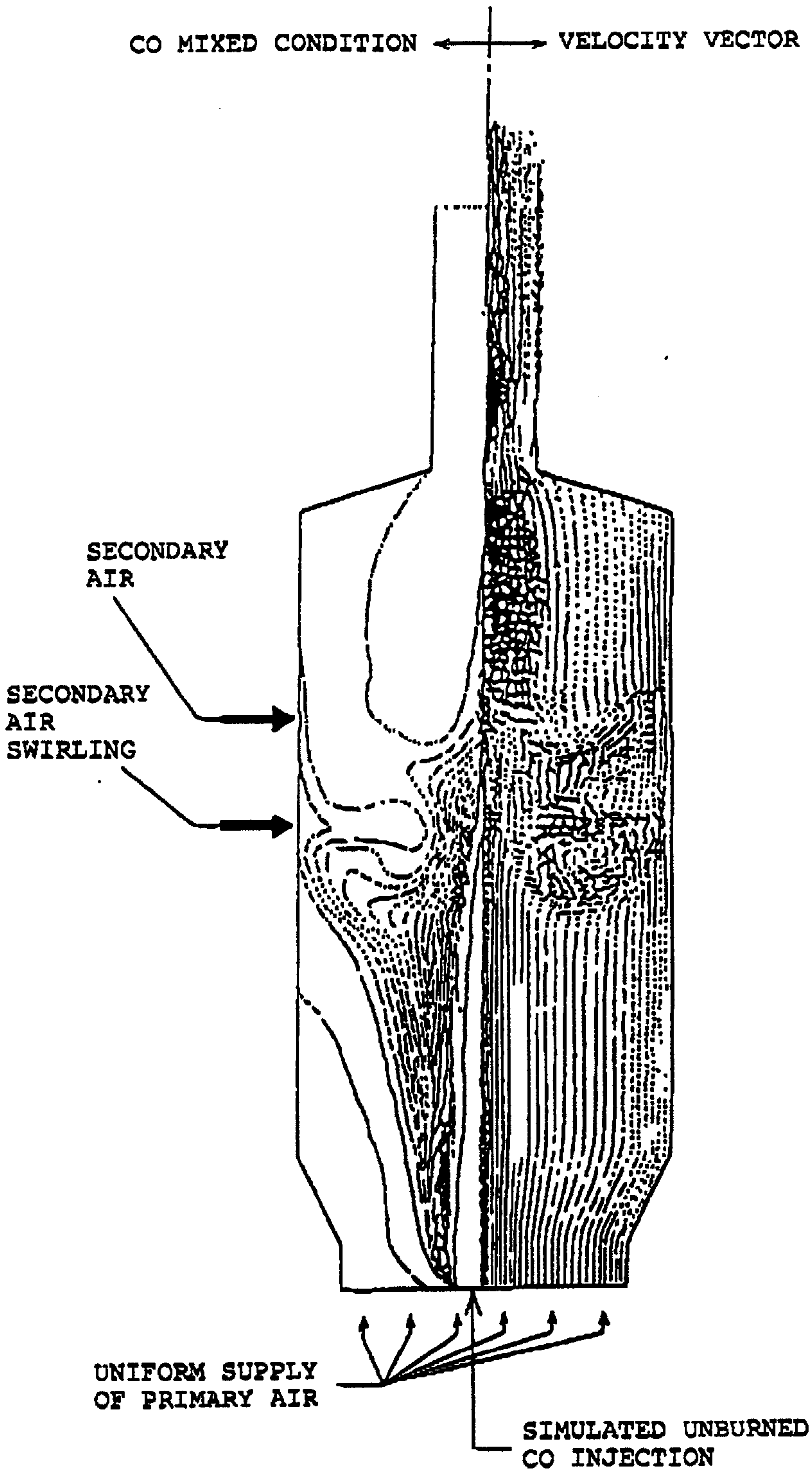

CO MIXED CONDITION
VELOCITY VECTOR
SECONDARY AIR
SECONDARY AIR SWIRLING
UNIFORM SUPPLY OF PRIMARY AIR
SIMULATED UNBURNED CO INJECTION

FIG. 4

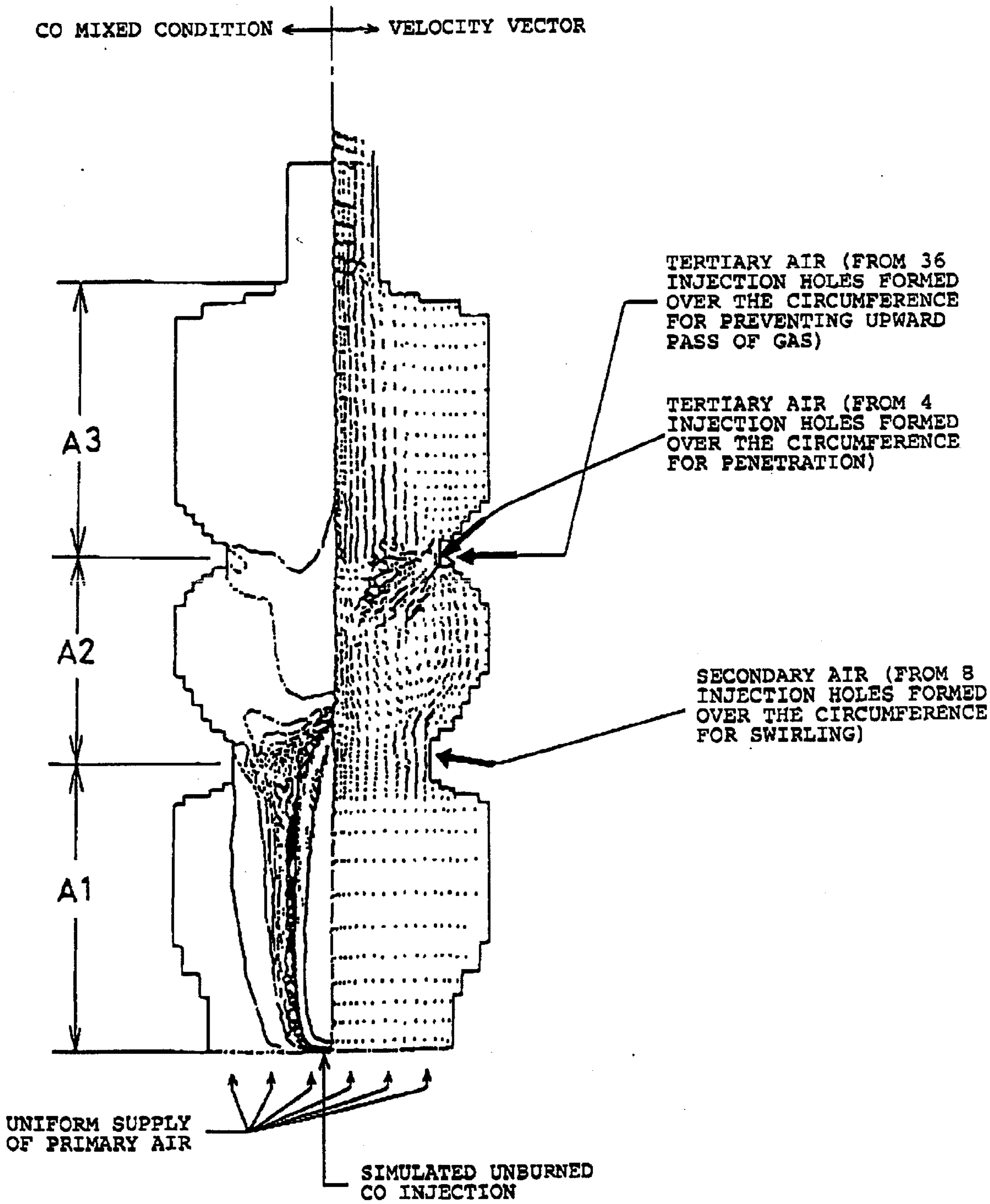

CO MIXED CONDITION
VELOCITY VECTOR
TERTIARY AIR (FROM 36 INJECTION HOLES FORMED OVER THE CIRCUMFERENCE FOR PREVENTING UPWARD PASS OF GAS)
TERTIARY AIR (FROM 4 INJECTION HOLES FORMED OVER THE CIRCUMFERENCE FOR PENETRATION)
A3
A2
SECONDARY AIR (FROM 8 INJECTION HOLES FORMED OVER THE CIRCUMFERENCE FOR SWIRLING)
A1
UNIFORM SUPPLY OF PRIMARY AIR
SIMULATED UNBURNED CO INJECTION

FIG. 5

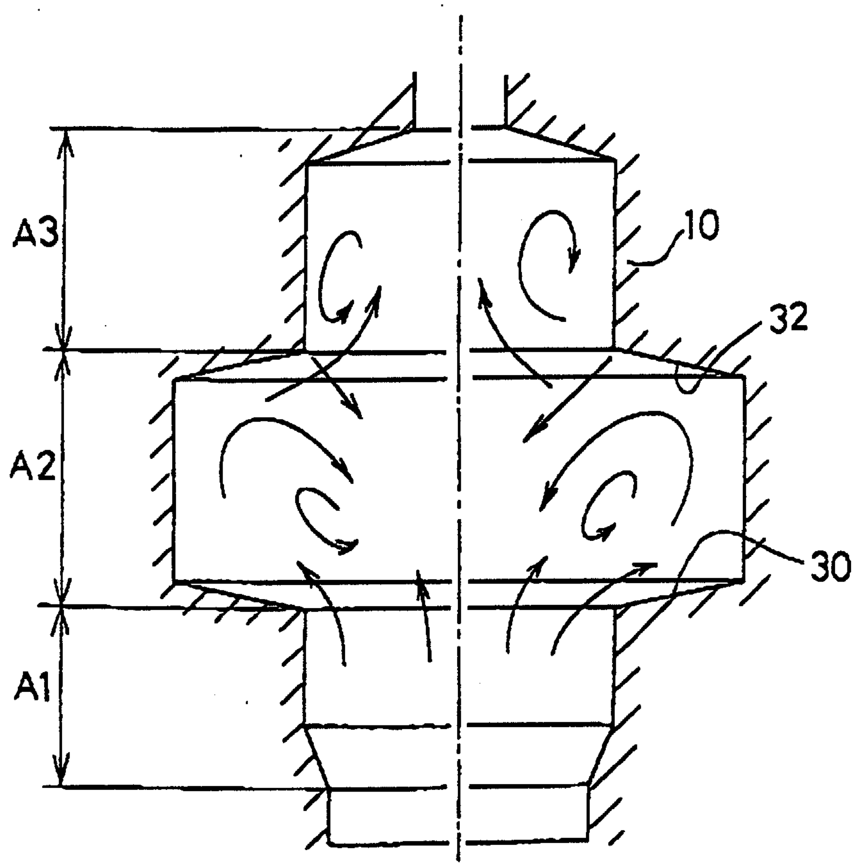


FIG. 6

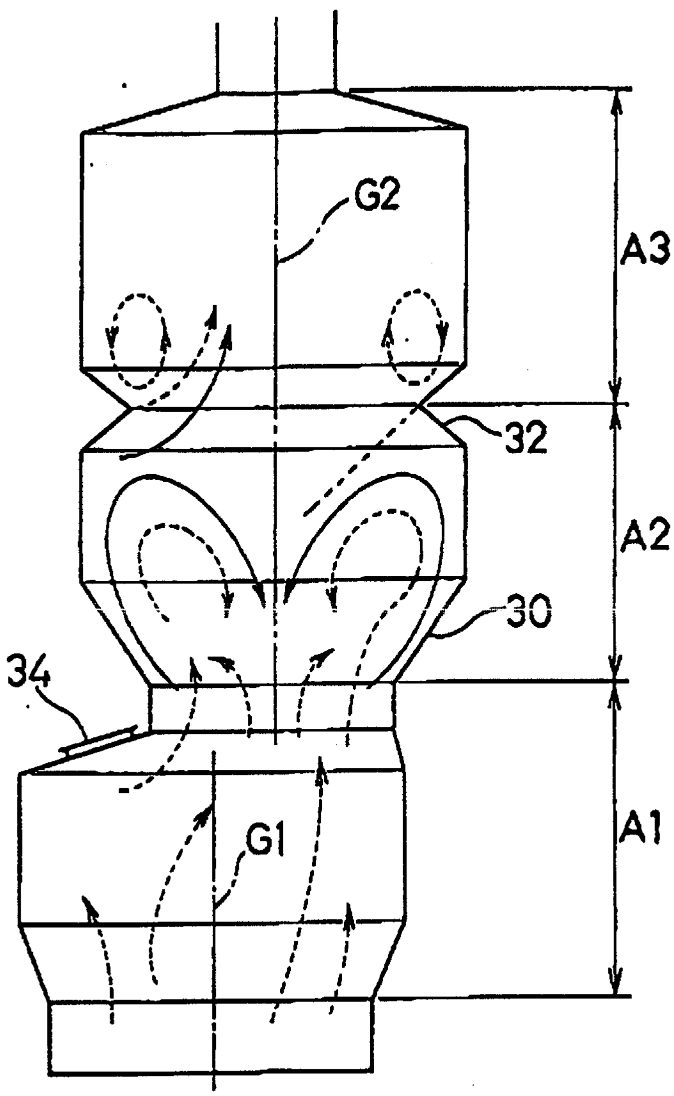


FIG. 7

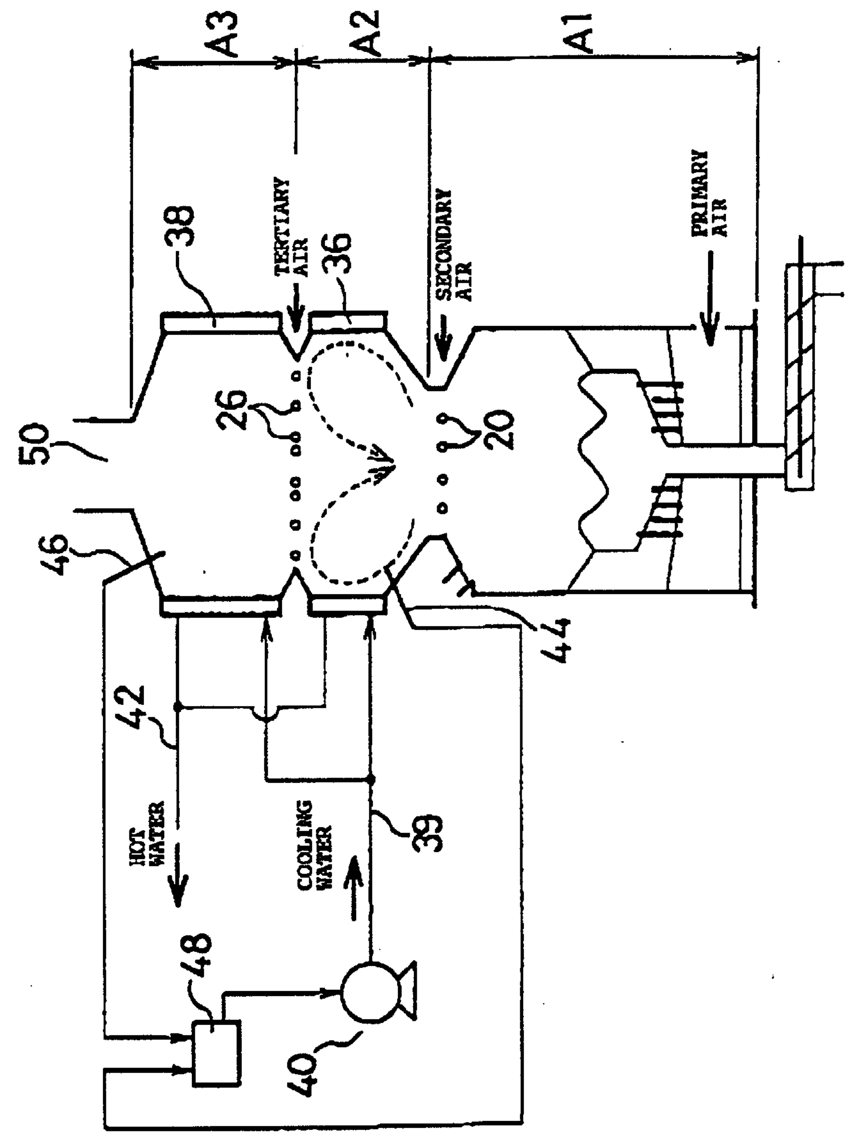

A3
A2
A1
38
TERTIARY AIR
36
SECONDARY AIR
PRIMARY AIR
50
26
20
46
44
42
HOT WATER
COOLING WATER
39
48
40

FIG. 8(a)

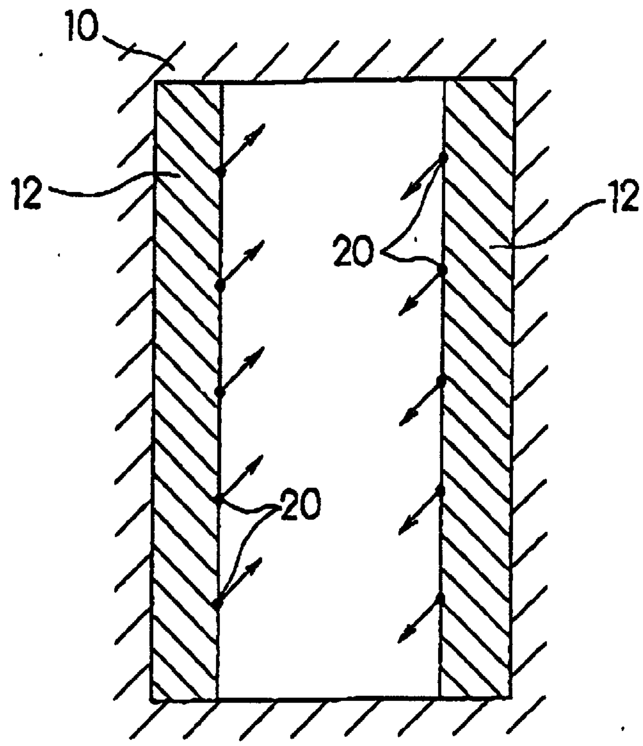


FIG. 8(b)

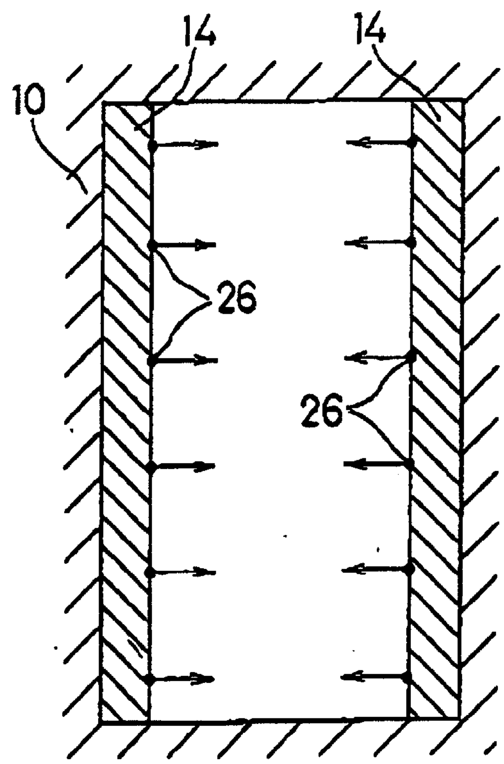


FIG. 9

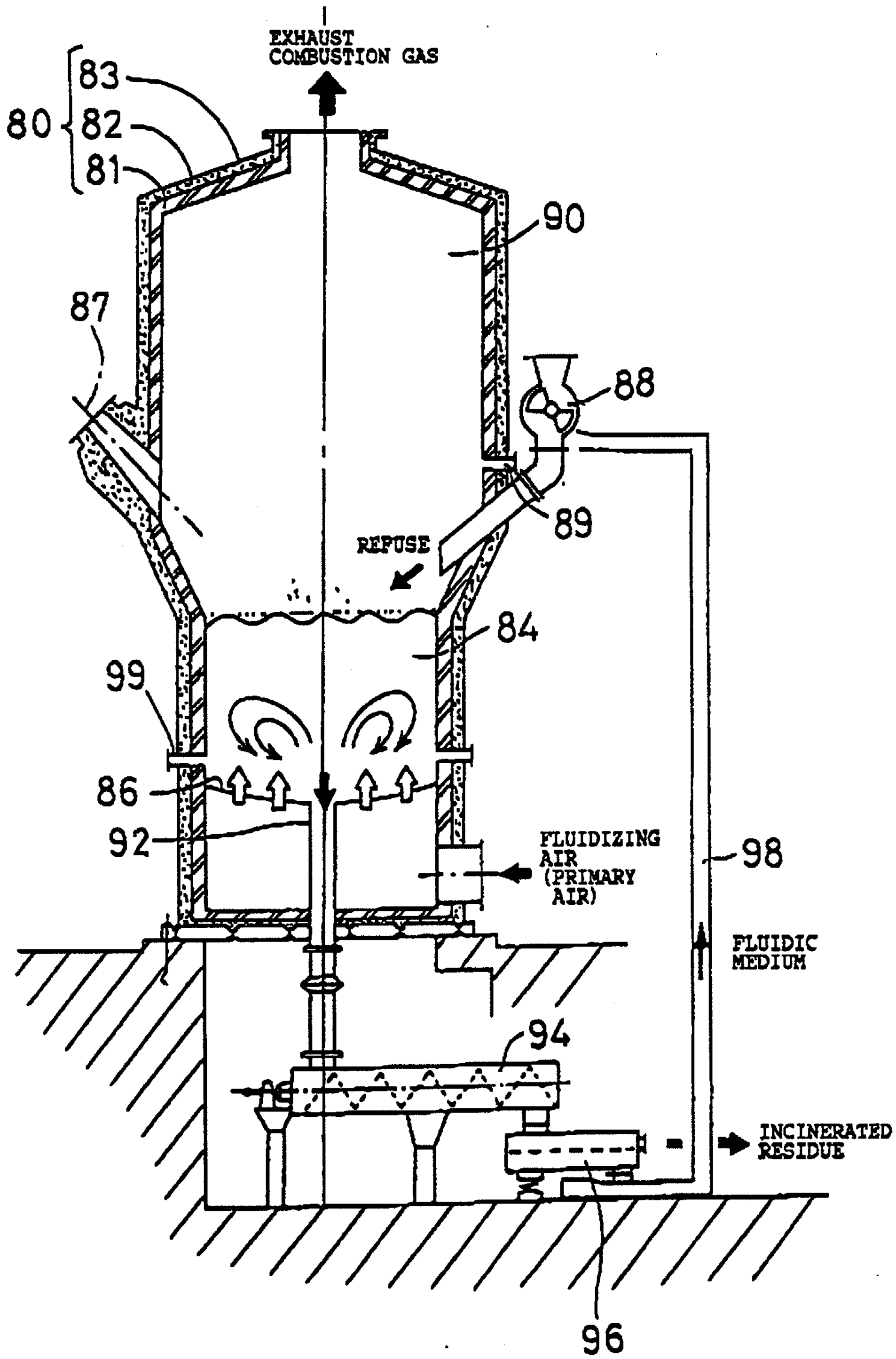
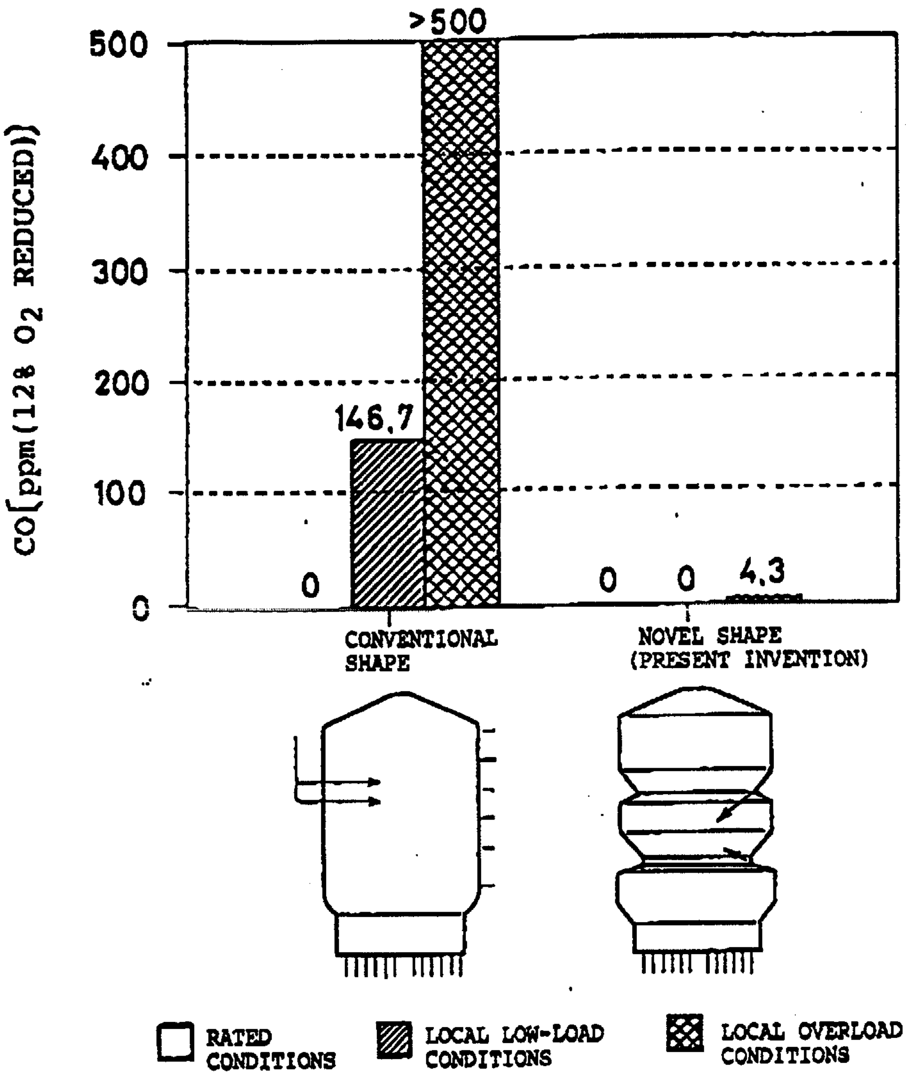

EXHAUST
COMBUSTION GAS
83
80
82
81
90
87
88
89
REFUSE
84
99
86
92
FLUIDIZING
AIR
(PRIMARY
AIR)
98
FLUIDIC
MEDIUM
94
INCINERATED
RESIDUE
96

FIG. 10



>500
500
400
300
200
100
0
CO[ppm(12% O2 REDUCED)]
146.7
0
0
0
4.3
CONVENTIONAL SHAPE
NOVEL SHAPE (PRESENT INVENTION)
RATED CONDITIONS
LOCAL LOW-LOAD CONDITIONS
LOCAL OVERLOAD CONDITIONS

FIG. 11