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(54) FUSION FURNACE, GASIFICATION FUSION FURNACE, AND METHOD OF PROCESSING WASTE

(57) The slagging combustion furnace (10) of the present invention includes a combustion chamber (11, 12, 13) for combusting a combustible gas containing ash and melting the ash, and a slag discharge port (17) for discharging molten slag (20) produced by melting the ash. The slag discharge port (17) is formed by refractory material which is replaceable.

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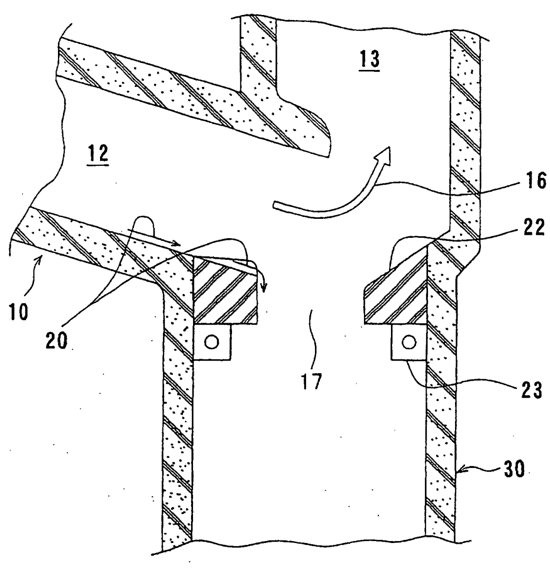

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Description

Technical Field

[0001] The present invention relates to a slagging combustion furnace and a gasification and slagging combustion system for being supplied with a gas produced in a gasification furnace or the like and containing ash and unburned carbon, and combusting the supplied gas at a high temperature to melt the ash into molten slag.

Background Art

[0002] There has been a demand for incinerating wastes including municipal wastes, industrial wastes, medical wastes, shredder dust, waste tires, and the like to reduce the volume of the wastes, and effectively utilizing heat of incineration of the wastes. Because incineration ash of the wastes normally contains harmful heavymetals, in order to discard the incineration ash in a landfill site, it is necessary to take some measures for solidifying heavy metal components. Further, there has been a demand for downsizing an overall waste treatment system. In order to solve the above problems, a gasification and melting furnace (gasification and slagging combustion system) which can recover various metals, melt ash to produce molten slag and recover the produced molten slag, and recover energy in the form of heat, electric power or the like has come into the limelight as a waste treatment system. The gasification and slagging combustion system is not a simple incineration treatment, but is a combination of pyrolysis gasification and high-temperature combustion, and is capable of performing material recycling.

[0003] FIG. 1 is a schematic view showing a conventional gasification andslagging combustion system whichisa combination of a fluidized-bed gasification furnace and a swirling-type slagging combustion furnace. As shown in FIG. 1, the gasification and slagging combustion system comprises a fluidized-bed gasification furnace 1 and a swirling-type slagging combustion furnace 10. In the gasification and slagging combustion system shown in FIG. 1, wastes are supplied to a fluidized bed 2 and gasified to produce a combustible gas containing unburned carbon and ash and having a temperature of about 500°C to about 600°C in the gasification furnace 1, and the produced combustible gas is introduced into the slagging combustion furnace 10 and combusted by a secondary air at a high temperature under a low air ratio of about 1.3 to about 1.5 to increase a temperature of the interior of the furnace to a melting point of ash or higher (for example, 1300°C or higher, preferably about 1350°C) in the swirling-type slagging combustion furnace 10. In this high-temperature condition, ash is collected on a wall surface of the furnace, and a flow of molten slag is formed. The molten slag is discharged through a slag discharge port 17 to the outside of the furnace. Then, the discharged molten slag is brought into contact with slag cooling water to form water-quenched slag.

[0004] On the other hand, a high-temperature combustion gas generated in the process in which ash content is melted to form molten slag is introduced into a waste heat boiler, a heat exchanger or the like in which thermal energy is recovered. In such gasification and slagging combustion system, the structure of the slagging combustion furnace affects melting state of ash and stable operation of the slagging combustion furnace, and hence it has been considered that the structure of the slagging combustion furnace is technically important for the overall gasification and slagging combustion system.

[0005] FIG. 2 is a schematic view of the conventional slagging combustion furnace. As shown in FIG. 2, reference numeral 10 represents the slagging combustion furnace 10, and the slagging combustion furnace 10 comprises a primary combustion chamber 11, a secondary combustion chamber 12, and a tertiary combustion chamber 13. A passage which is formed within the slagging combustion furnace and allows a combustion gas 16 to pass therethrough comprises a substantially V-shaped passage as shown by the arrow, and a slag discharge port 17 is formed at the lowermost position of the V-shaped passage.

[0006] A produced gas 14 produced by gasification in the gasification furnace 1 (see FIG. 1) and containing unburned carbon and ash, or a mixed gas of the produced gas 14 and combustion gas is introduced into the upper part of the primary combustion chamber 11 in a direction tangential to an inner wall surface of the slagging combustion furnace 10. Combustion air 15 is also introduced into the primary combustion chamber 11 in a direction tangential to the inner wall surface of the slagging combustion furnace 10. Thus, the produced gas 14 or the mixed gas of the produced gas 14 and the combustion gas is mixed with the combustion air 15, and is combusted while forming a swirling flow of the gas, and moves to the secondary combustion chamber 12 and is combusted at a high temperature of 1200 to 1400°C, preferably about 1350°C in the secondary combustion chamber 12 and then the tertiary combustion chamber 13. Then, exhaust gas 16' is discharged from the tertiary combustion chamber 13, and is then introduced into a waste heat boiler or the like (not shown in the drawing) . In FIG. 2, reference numerals 18 and 19 represent an auxiliary burner, respectively. In the above example, both of the produced gas 14 and the combustion air 15 are introduced in the direction tangential to the inner wall surface of the furnace. However, one of the produced gas 14 and the combustion air 15 may be introduced in a direction tangential to the inner wall surface of the furnace to thus generate a swirling flow of the gas, and the other of the produced gas 14 and the combustion air 15 may be blown into the formed swirling flow, thereby combusting while having mixed with each other.

[0007] As described above, the produced gas 14 containing unburned carbon and ash and the combustion air 15 introduced into the upper part of the primary combustion chamber 11 are mixed with each other while forming a swirling flow of the gas in the primary combustion chamber 11, and the produced gas 14 is combusted in the primary combustion chamber 11, and then moves to the secondary combustion chamber 12 and the tertiary combustion chamber 13. Ash is collected on the inner wall surface of the furnace due to the swirling flow in the furnace, and is melted at a high temperature to form molten slag 20. The molten slag flows downwardly on the furnace bottom, and falls down from the slag discharge port 17 through a slag discharge chute 30 to the outside of the furnace. Then, the discharged molten slag 20 is brought into contact with slag cooling water (not shown in the drawing) to form water-quenched slag, and the granulated slag is recovered.

[0008] FIG. 3 is a view showing the furnace bottom having the slag discharge port of the slagging combustion furnace in an example. As shown in FIG. 3, the molten slag 20 flowing downwardly on the wall surface of the slagging combustion furnace 10 is collected at the furnace bottom, and falls down along an inner wall surface 17a of the slag discharge port 17. Thus, the inner wall surface 17a of the slag discharge port 17 is concentratedly exposed to the molten slag 20 having a high temperature to cause damage of the inner wall surface 17a due to melting. When such melting damage progresses, it is necessary to replace the inner wall of the slag discharge port 17 with a new one. Further, the slag discharge port 17 is a boundary between the high-temperature secondary and tertiary combustion chambers 12 and 13, and the low-temperature slag discharge chute 30 (the slag discharge chute 30 is cooled to a low temperature because slag cooling water is in the lower part of the slag discharge chute 30), and hence refractory material is subjected to severe conditions because of the formation of temperature gradient and is liable to be damaged or broken. However, because the inner wall of the slag discharge port 17 is integrally formed with the inner wall of the slagging combustion furnace 10, the replacement work of the inner wall of the slag discharge port 17 is not easy and is troublesome.

[0009] Alternatively, it may be considered that the inner wall of the slag discharge port 17 is formed by refractory material which is resistant to a thermal wear and a high temperature as preventive measures against a thermal wear and a thermal damage. However, because the inner wall of the slag discharge port 17 is integrally formedwith the inner wall of the slagging combustion furnace 10, it has been difficult to form only the inner wall of the slag discharge port 17 by refractory material which is resistant to a thermal wear and a high temperature. Further, since the refractory material which is resistant to a thermal wear and a high temperature is expensive, it is uneconomical to form the entire inner wall of the slagging combustion furnace 10 by the refractory material which is resistant to a thermal wear and a high temperature.

[0010] Further, in order to reduce the amount of thermal wear, water tubes may be provided on the inner wall of the slag discharge port 17. However, in this case, the inner wall surface 17a of the slag discharge port 17 is cooled excessively, and hence the molten slag 20 is adhered to the inner wall surface 17a and solidified thereon to form aggregated slag 21 as shown in FIG. 3. In the worst case, the slag discharge port 17 is clogged with the aggregated slag. Further, in this case, if the refractory material is not dried and burned, the refractory material does not display its innate strength. Therefore, when the refractory material is cooled excessively by the water tubes, the refractory material is liable to be damaged or broken due to a shortage of strength.

[0011] FIG. 4 is a second view showing the slag discharge port of the slagging combustion furnace 10 in another example. As shown in FIG. 4, the inner wall of the slag discharge port 17 has the same height in an entire circumference thereof. Specifically, the height h_1 of the inner wall at the upstream side of the flow of the combustion gas 16 is equal to the height h_2 of the inner wall at the downstream side of the flow of the combustion gas 16 ($h_1=h_2$). That is, the upper end of the slag discharge port 17 is located at the same level, and the upper surface 17b of the furnace bottom at an outer circumferential portion around the slag discharge port 17 is inclined downwardly toward the slag discharge port 17. Therefore, the combustion gas 16 which flows at the upstream side of the slag discharge port 17 along the upper surface 17b at the outer circumferential portion around the slag discharge port 17 collides with the inner wall surface 17a of the slag discharge port 17 to thus generate a turbulent flow of the gas in the slag discharge port 17. This turbulent flow has a bad influence on discharge conditions of the molten slag discharged through the slag discharge port 17.

[0012] As one of attendant problems, the molten slag 20 is adhered to the inner wall surface 17a of the slag discharge port 17 and solidified thereon to form aggregated slag 21 (see FIG. 3). In the worst case, the slag discharge port 17 is clogged with the aggregated slag, or the combustion gas 16 containing harmful components is discharged through the slag discharge port 17 to the outside of the slagging combustion furnace, thus contaminating slag cooling water.

Disclosure of Invention

[0013] The present invention has been made in view of the above drawbacks. It is therefore an object of the present invention to provide a slagging combustion furnace and a gasification and slagging combustion system which allows an inner wall of a slag discharge port to be replaced easily with a new one if the inner wall of the slag discharge port is damaged by melting, allows the inner wall of the slag discharge port to be less susceptible to a thermal wear or a breakage, and can prevent molten slag from being adhered to the inner wall of the slag discharge port or being solidified thereon due to an excessive cooling of the slag discharge port.

[0014] Another object of the present invention is to provide a slagging combustion furnace and a gasification and slagging combustion system in which a turbulent flow of the gas is not generated in the slag discharge port of the slagging combustion furnace and discharge conditions of the molten slag are not affected.

[0015] Still another object of the present invention is to provide a slagging combustion furnace and a gasification and slagging combustion system which allows adhesion or solidification of the molten slag at the slag discharge port to be detected, can prevent the slag discharge port from being clogged, or can dissolve clogging of the slag discharge port.

[0016] In order to achieve the above obj ect of the present invention, according to an aspect of the present invention, there is provided a slagging combustion furnace comprising: a combustion chamber for combusting a combustible gas containing ash and melting the ash; and a slag discharge port for discharging molten slag produced by melting the ash; wherein the slag discharge port is formed by refractory material which is replaceable.

[0017] With the above arrangement, because a slag discharge port is formed by a replaceable slag discharge port block which is a distinct member different from a furnace wall of a slagging combustion furnace, the slag discharge port block can be produced in advance using refractory material having a high resistance to a thermal wear and a high temperature through a predetermined manufacturing process (for example, a forming process and a drying process) in a plant. Thus, the newly produced slag discharge port block is carried into the site where the slagging combustion furnace is placed, and the slag discharge port block which has been damaged by melting or broken for some cause can be easily replaced with the newly produced slag discharge port block. Further, since the slag discharge port block is composed of refractory material (for example, high chromium refractory material) which is resistant to a thermal wear and a high temperature, the wall of the slag discharge port can be prevented from thermal wear or breakage. Further, since the portion around the slag discharge port is formed by the slag discharge port block, the slag discharge port is not cooled excessively because the refractory material is not required to be cooled or slight cooling of the refractory material is sufficient by water tubes, unlike a conventional discharge port, thus preventing molten slag from being adhered to the inner wall of the slag discharge port or being solidified thereon.

[0018] According to one aspect of the present invention, the slag discharge port comprises an opening formed at a central portion of a slag discharge port block, and at least one slag discharge groove extending from an outer peripheral portion of the slag discharge port block at the upstream side of a flow of combustion gas to the slag discharge port is formed in an upper surface of the slag discharge port block.

[0019] With the above arrangement, because a slag discharge groove extending from an outer periphery of the slag discharge port block at an upstream side of a combustion gas passage to the slag discharge port is formed in an upper surface of the slag discharge port block, molten slag flowing downwardly on the inner wall surface of the slagging combustion furnace flows through the slag discharge groove into the slag discharge port, and falls down through the slag discharge port. Thus, the discharge position of the molten slag is fixed. Further, since the molten slag flows concentratedly, even if the scale of system or operational condition of the system is such that the amount of slag to be generated is small, the molten slag is less susceptible to being cooled. Thus, the molten slag is prevented from being adhered to the surface of the slag discharge port block or being solidified thereon.

[0020] According to one aspect of the present invention, the upper surface of the slag discharge port block is a slant surface which is inclined downwardly toward the slag discharge port, and an upper end of an outer wall forming the slag discharge port at the upstream side of the flow of the combustion gas is higher than an upper end of the inner wall forming the slag discharge port at the downstream side of the flow of the combustion gas.

[0021] With the above arrangement, because the upper surface of the slag discharge port block is formed into a slant surface which is inclined downwardly toward the slag discharge port, and the height of the inner wall of the slag discharge port at the upstream side of a flow of the combustion gas is higher than the height of the inner wall of the slag discharge port at the downstream side of the flow of the combustion gas, the combustion gas which has flowed into the upper surface of the slag discharge port block at the upstream side of the flow of the combustion gas passes through a location above the slag discharge port, and flows along the upper surface of the slag discharge port at the downstream side of the slag discharge port. Thus, since the combustion gas does not collide with the inner wall surface of the slag discharge port, the combustion gas can be prevented from flowing into the slag discharge port. Further, the gas flownear the slag discharge port is smoothed, and hence a fall position of the discharged molten slag is not deviated. If this deviation is large, the slag is attached to the inner surface of the slag discharge chute.

[0022] According to one aspect of the present invention, the upper surface of the slag discharge port block is a slant surface which is inclined downwardly toward an outer circumferential portion of the slag discharge port block.

[0023] Because the upper surface of the slag discharge port block is formed into a slant surface which is inclined downwardly toward the outer periphery of the slag discharge port block, the combustion gas which has flowed into the upper surface of the slag discharge port block at the upstream side of the flow of the combustion gas moves toward the slag discharge port in an upward flow. Thus, the combustion gas is prevented from flowing into the slag discharge port. Further, because the upper surface of the slag discharge port block is formed into the slant surface which is inclined downwardly toward the outer periphery of the slag discharge port block, molten slag attached to the upper surface is entirely collected at the outer circumferential portion, and molten slag flowing downwardly on the inner wall surface of the slagging combustion furnace is collected at the outer circumferential portion of the slag discharge port block. Then, the molten slag flows through the slag discharge groove into the slag discharge port, and falls down through the slag discharge port. Thus, the molten slag is prevented from being adhered to the surface of the slag discharge port block or being solidified thereon.

[0024] According to one aspect of the present invention, the slag discharge port block comprises a plurality of block pieces.

[0025] With the above arrangement, since the slag discharge port block is composedof apluralityofblock-pieces, the slag discharge port block can be easily produced and can be easily transported. Further, even if the slag discharge port block is damaged or broken, only the block piece which has been damaged or broken can be replaced. Thus, the replacement of the block piece is facilitated.

[0026] According to the present invention, there is provided a gasification and slagging combustion system, comprising: a gasification furnace for gasifying-wastes to produce a combustible gas containing the ash and the unburned carbon; and a slagging combustion furnace for combusting the combustible gas containing ash and unburned carbon and melting the ash; the slagging combustion furnace comprising any one of the above slagging combustion furnaces.

[0027] As described above, as a slagging combustion furnace of a gasification and slagging combustion system, by using any of the above slagging combustion furnaces, the slagging combustion furnace which exhibits the above features and good operational efficiency can be constructed.

[0028] Further, in order to solve the above problems, according to another aspect of the present invention, there is provided a slagging combustion furnace comprising: a combustion chamber for combusting a combustible gas containing ash and melting the ash; and a slag discharge port for discharging molten slag produced by melting the ash; wherein the height of an inner wall forming the slag discharge port is higher at the upstream side of a flow of combustion gas than at the downstream side of the flow of the combustion gas.

[0029] With the above arrangement, because the height of the inner wall of the slag discharge port at the upstream side of the flow of the combustion gas is higher than the height of the inner wall of the slag discharge port at the downstream side of the flow of the combustion gas, the combustion gas which has flowed along the upper surface at the upstream side of the slag discharge port passes through a location above the slag discharge port, and reaches the upper surface at the downstream side of the slag discharge port. Thus, since the combustion gas flows smoothly without causing the combustion gas to collide with the inner wall of the slag discharge port and without generating a turbulent flow at the location near the slag discharge port, unlike the conventional, the flow of the combustion gas does not affect adversely the discharge state of the molten slag. Because the combustion gas passes through a location above the slag discharge port, and a flow direction of the combustion gas is changed by the upper surface at the downstream side of the slag discharge port, the amount of the combustion gas flowing into the slag discharge port can be greatly reduced.

[0030] According to one aspect of the present invention, an upper surface at an outer circumferential portion around the slag discharge port is a slant surface inclined upwardly toward the slag discharge port, and at least one slag discharge groove extending to the slag discharge port is formed in the slant surface at the upstream side of the flow of the combustion gas.

[0031] With the above arrangement, because the upper surface at an outer circumferential portion around the slag discharge port is formed into a slant surface which is inclined upwardly toward the slag discharge port, and the height of the inner wall of the slag discharge port and the inclination angle of the slant surface at the upstream side of the flow of the combustion gas are set such that the combustion gas flowing along the slant surface at the upstream side reaches the slant surface at the downstream side, the combustion gas which has flowed into the upper surface at the upstream side of the slag discharge port passes though a location above the slag discharge port, and reaches the upper surface at the downstream side of the slag discharge port. Thus, since the combustion gas flows smoothly without causing the combustion gas to collide with the inner wall of the slag discharge port and without generating a turbulent flow at the location near the slag discharge port, the flow of the combustion gas does not affect adversely the discharge state of the molten slag.

[0032] Because the upper surface at an outer circumferential portion around the slag discharge port is formed into a slant surface which is inclined upwardly toward the slag discharge port, the combustion gas which has flowed into the upper surface at the upstream side of the slag discharge port moves toward the slag discharge port in an upward flow. Thus, the combustion gas is prevented from flowing into the slag discharge port.

[0033] Because a slag discharge groove extending from a slant surface at the upstream side of the combustion gas passage to the slag discharge port is formed in the upper surface at an outer circumferential portion around the slag discharge port, molten slag flowing downwardly on the inner wall of the slagging combustion furnace flows through the slag discharge groove into the slag discharge port. Thus, the discharge position of the molten slag is fixed. Because molten slag flows concentratedly through a slag discharge groove, even if the scale of system or operational condition of the system is such that the amount of slag to be generated is small, the molten slag is less susceptible to being cooled. Thus, the molten slag is prevented from being adhered to the surface of the radially outer portion of the slag discharge port or being solidified thereon.

[0034] According to one aspect of the present invention, there is provided a waste treatment method comprising: gasifying wastes to produce a combustible gas containing ash in a fluidized-bed furnace; combusting the combustible gas and melting the ash to form molten slag in a slagging combustion furnace, the slagging combustion furnace comprising a primary combustion chamber, a secondary combustion chamber and a tertiary combustion chamber; trapping the molten slag on an inner wall surface of the primary combustion chamber and flowing the trapped molten slag downwardly into the secondary combustion chamber; flowing the molten slag on the inner wall surface of the secondary combustion chamber and discharging the molten slag through a slag discharge groove formed in a slag discharge port block to a slag discharge port formed in the slag discharge port block, the slag discharge port block being disposed at a lowermost part of the secondary combustion chamber, the slag discharge groove being formed at the primary combustion chamber side; trapping molten slag on an inner wall surface of the tertiary combustion chamber from combustion gas introduced into the tertiary combustion chamber, and then discharging the trapped molten slag through the slag discharge groove to the slag discharge port block; and supplying the molten slag discharged from the slag discharge groove to a water quenching trough and cooling the discharged molten slag in the water quenching trough.

[0035] According to the present invention, because a slag discharge groove is formed only at the primary combustion chamber side, the molten slag is concentratedly discharged through the slag discharge groove and part of combustion gas flows through the slag discharge groove to prevent the slag from being cooled.

[0036] According to another aspect of the present invention, there is provided a waste treatment method comprising: gasifying wastes to produce a combustible gas containing ash in a fluidized-bed furnace; combusting the combustible gas and melting the ash to form molten slag in a slagging combustion furnace, the slagging combustion furnace comprising a primary combustion chamber, a secondary combustion chamber and a tertiary combustion chamber; trapping the molten slag on a wall surface of the primary combustion chamber and flowing the trapped molten slag downwardly into the secondary combustion chamber; flowing the molten slag on the wall surface of the secondary combustion chamber to a slag discharge groove and discharging the molten slag through the slag discharge groove, a slag discharge port block disposed at a lowermost part of the secondary combustion chamber having a slag discharge groove at the primary combustion chamber side; trapping molten slag on a wall surface of the tertiary combustion chamber from combustion gas introduced into the tertiary combustion chamber, and then discharging the trapped molten slag through the slag discharge groove to the slag discharge port; cooling and solidifying the molten slag discharged from the slag discharge groove; and drawing steam generated by the cooling and solidifying of the molten slag and combustion gas through the slag discharge port of the secondary combustion chamber to form a mixed gas, and introducing the mixed gas to the tertiary combustion chamber.

[0037] According to the present invention, because the combustion gas is drawn through the slag discharge port together with steam generated by cooling of slag and solidification of the slag, the slag discharge port and a portion around the slag discharge port can be prevented from being cooled by the steam, and can be kept at a high temperature.

[0038] According to one aspect of the present invention, there is provided a waste treatment method comprising: gasifying wastes to produce a combustible gas containing ash in a fluidized-bed furnace; combusting the combustible gas and melting the ash to form molten slag in a slagging combustion furnace, the slagging combustion furnace comprising a primary combustion chamber, a secondary combustion chamber and a tertiary combustion chamber; trapping the molten slag on a wall surface of the primary combustion chamber and flowing the trapped molten slag downwardly into the secondary combustion chamber; flowing the molten slag on the wall surface of the secondary combustion chamber to a slag discharge groove and discharging the molten slag through the slag discharge groove, a slag discharge port block disposed at a lowermost part of the secondary combustion chamber having the slag discharge groove at the primary combustion chamber side; trapping molten slag on a wall surface of the tertiary combustion chamber from combustion gas introduced into the tertiary combustion chamber, and then flowing the molten slag on the wall surface of the tertiary combustion chamber to the slag discharge port block and discharging the molten slag through the slag discharge groove; cooling the molten slag discharged through the slag discharge groove in a slag discharge chute; and detecting a pressure differential between an interior of the secondary combustion chamber and an interior of the slag discharge chute; wherein when the pressure differential exceeds a set value, a secondary combustion chamber burner provided at the secondary combustion chamber is operated to heat a portion around the slag discharge port.

[0039] According to the present invention, a pressure differential between the interior of the slag discharge chute and the interior of the secondary combustion chamber is detected, and if the pressure differential exceeds a set value, then an inclination of clogging of the slag discharge port by attachment of slag and solidification of the slag is judged, and the slag discharge port and a portion around the slag discharge port are heated by a secondary combustion chamber burner to prevent the slag discharge port from being clogged.

[0040] According to one aspect of the present invention, there is provided a waste treatment apparatus comprising: a fluidized-bed furnace for gasifying wastes to produce a combustible gas containing ash; a slagging combustion furnace for combusting the combustible gas and melting the ash to form molten slag, the slagging combustion furnace comprising a primary combustion chamber, a secondary combustion chamber, a tertiary combustion chamber, and a slag discharge port block at a lowermost part of the secondary chamber and having a slag discharge groove at the primary combustion chamber side; wherein the molten slag is trapped on a wall surface of the primary combustion chamber and the trapped molten slag flows downwardly into the secondary combustion chamber, the molten slag flows on the wall surface of the secondary combustion chamber to the slag discharge groove and the molten slag is discharged from the slag discharge groove, molten slag is trapped on a wall surface of the tertiary combustion chamber from combustion gas introduced into the tertiary combustion chamber, and then the trapped molten slag flows downwardly to the slag discharge port block and is discharged from the slag discharge groove; a slag discharge chute disposed below the slag discharge port block for cooling the molten slag discharged from the slag discharge groove; and a pressure instrument for detecting a pressure differential between an interior of the secondary combustion chamber and an interior of the slag discharge chute; wherein when the pressure differential between the interior of the secondary combustion chamber and the interior of the slag discharge chute exceeds a set value, a secondary combustion chamber burner provided at the secondary combustion chamber is operated to heat a portion around the slag discharge port.

[0041] According to the present invention, a pressure differential between the interior of the slag discharge chute and the interior of the secondary combustion chamber is detected, and if the pressure differential exceeds a set value, then an inclination of clogging of the slag discharge port by attachment of slag and solidification of the slag is judged, and the slag discharge port and a portion around the slag discharge port are heated by a secondary combustion chamber burner to prevent the slag discharge port from being clogged.

Brief Description of Drawings

[0042]

FIG. 1 is a schematic view showing a conventional gasification and slagging combustion system;

FIG. 2 is a schematic view of the conventional slagging combustion furnace;

FIG. 3 is a view showing a slag discharge port and its vicinity of a slagging combustion furnace in an example;

FIG. 4 is a view showing a slag discharge port and its vicinity of a slagging combustion furnace in another example;

FIG. 5 is a view showing a slag discharge port and its vicinity of a slagging combustion furnace according to the present invention;

FIGS. 6A through 6C are views showing a slag discharge port block, and FIG. 6A is a cross-sectional view (taken along line VI_A-VI_A of FIG. 6B), FIG. 6B is a plan view, and FIG. 6C is a cross-sectional view (taken along line VI_C-VI_C of FIG. 6B);

FIG. 7 is a view showing a slag discharge port block of a slagging combustion furnace according to an example of the present invention;

FIG. 8 is a view showing a slag discharge port and its vicinity of a slagging combustion furnace according to the present invention;

FIG. 9A is a cross-sectional view of a slag discharge port block shown in FIG. 8 (a cross-sectional view taken along line IX_A-IX_A of FIG. 9B), and FIG. 9B is a plan view of the slag discharge port block shown in FIG. 8;

FIG. 10 is a view showing a slag discharge port of a slagging combustion furnace according to another embodiment of the present invention;

FIG. 11 is an enlarged cross-sectional view showing an essential part of FIG. 10;

FIG. 12 is a view showing a slag discharge port of a slagging combustion furnace according to another embodiment of the present invention;

FIG. 13A is a cross-sectional view showing the slag discharge port, and FIG. 13B is a plan view;

FIG. 14 is a view showing a slagging combustion furnace according to still another embodiment of the present invention;

FIGS. 15A through 15C are views showing the slag discharge port block, and FIG. 15A is a perspective view of the slag discharge port block, FIG. 15B is a cross-sectional view taken along line XV_B-XV_B of FIG. 15A, and FIG. 15C is a cross-sectional view taken along line XV_C-XV_C of FIG. 15A;

FIG. 16 is an enlarged cross-sectional view showing an essential part of FIG. 14;

FIGS. 17A and 17B are cross-sectional views showing the manner in which molten slag flows through the slag discharge port; and

FIG. 18 is a view showing a slagging combustion furnace according to still another embodiment of the present invention.

Best Mode for Carrying Out the Invention

[0043] Embodiments of the present inventionwill be described below with reference to the drawings.

[0044] FIG. 5 is a view showing a slag discharge port and its vicinity of a slagging combustion furnace according to the present invention. As shown in FIG. 5, a slag discharge port block 22 is provided at the furnace bottom between the secondary combustion chamber 12 and the tertiary combustion chamber 13 in the slagging combustion furnace 10. Reference numeral 23 represents water tubes 23 provided under the slag discharge port block 22.

[0045] FIGS. 6A through 6C show the slag discharge port block 22, and FIG. 6A is a cross-sectional view (taken along line VI_A-VI_A of FIG. 6B), FIG. 6B is a plan view, and FIG. 6C is a cross-sectional view (taken along line VI_C-VI_C of FIG. 6B). The slag discharge port block 22 is made of refractory material which is resistant to a thermal wear and a high temperature. For example, the refractory material comprises a high chromium refractory material containing chromium of 60% ormore. The slag discharge port block 22 has a slag discharge port 17 at the central portion thereof. The upper surface 22a of the slag discharge port block 22 is formed into a slant surface which is inclined downwardly toward the slag discharge port 17, and an inner circumferential surface 22c constituting an inner wall surface of the slag discharge port 17 is formed into a vertical surface.

[0046] In the inner circumferential surface 22c of the slag discharge port block 22 constituting the inner wall surface of the slag discharge port 17, the height h_1 at the upstream side (the arrow C side) of a flow of the combustion gas 16 is higher than the height h_2 at the downstream side (the arrow D side) of the flow of the combustion gas 16 (h_1>h_2). The slag discharge port block 22 has a slag discharge groove 22d formed in the upper surface 22a such that the slag discharge groove 22d extends from the outer periphery at the upstream side of the flow of the combustion gas 16 to the slag discharge port 17. The width of the slag discharge groove 22d is wider at the outer circumferential side than at the slag discharge port 17 side, and the slag discharge groove 22d has a substantially semicircular cross section.

[0047] In the case where the slag discharge port block 22 having the above structure is provided at the opening portion formed at the furnace bottom between the secondary combustion chamber 12 and the tertiary combustion chamber 13, the combustion gas 16 flowing from the secondary combustion chamber 12 to the tertiary combustion chamber 13 flows into the upper surface 22a of the slag discharge port block 22 from the upstream side (the arrow C side) of the slag discharge port, and flows through a location above the slag discharge port 17 to the downstream side (the arrow D side) of the slag discharge port. As described above, in the inner circumferential surface 22c, the height h_1 at the upstream side is higher than the height h_2 at the downstream side (h_1>h_2). Therefore, as shown in FIG. 6A, an inclination angle of the upper surface 22a at the upstream side is set such that the combustion gas 16 which has passed through the location above the slag discharge port 17 does not collide with the inner circumferential surface 22c, and hence the combustion gas 16 flows along the upper surface 22a at the downstream side into the tertiary combustion chamber 13. Therefore, the combustion gas 16 is prevented from being flowing into the slag discharge port 17.

[0048] Because the slag discharge port block 22 is composed of a distinct member different from the furnace wall of the slagging combustion furnace, the slag discharge port block 22 is not cooled excessively by the water tubes 23, and thus the molten slag 20 is not adhered to the slag discharge port block and is not solidified thereon due to an excessive cooling. Further, since the slag discharge groove 22d extending from the outer periphery at the upstream side to the slag discharge port 17 is formed in the upper surface 22a of the slag discharge port block 22, the molten slag 20 flowing downwardly on the inner wall surface of the slagging combustion furnace 10 collects in the slag discharge groove 22d, and then flows into the slag discharge port 17. Thus, the molten slag 20 is prevented from being adhered to the surface of the slag discharge port block 22 and being solidified thereon. The number of the slag discharge grooves 22d may be one or plural.

[0049] The length of the inner circumferential surface 22c of the slag discharge port block 22 constituting the inner wall surface of the slag discharge port 17 is preferably short in view of preventing the molten slag 20 from being adhered thereto or solidified thereon. For example, as shown in FIG. 7, the height h of the slag discharge port block 22 should be short.

[0050] FIG. 8 is a view showing a slag discharge port and its vicinity of a slagging combustion furnace according to the present invention. FIG. 9A is a cross-sectional view of the slag discharge port block (cross-sectional view taken along line IX_A-IX_A of FIG. 9B), and FIG. 9B is a plan view of the slag discharge port block 22 shown in FIG. 8. As shown in FIGS. 9A and 9B, the slag discharge port block 22 has an upper surface 22a which is a slant surface inclined downwardly toward the outer circumferential portion thereof. A slag discharge groove 22d extending from an outer periphery at the upstream side of a flow of the combustion gas to the slag discharge port 17 is formed in the upper surface 22a.

[0051] Since the upper surface 22a of the slag discharge port block 22 is formed into the slant surface which is inclined downwardly toward the outer periphery of the slag discharge port block 22, molten slag attached to the upper surface 22a is entirely collected at the outer circumferential portion of the slag discharge port block

22. Then, the collected molten slag flows together with molten slag 20 flowing on the inner wall surface of the secondary combustion chamber 12 and the tertiary combustion chamber 13 of the slagging combustion furnace 10 into the connecting portion between the inner wall surface of the slagging combustion furnace 10 and the outer circumferential surface of the slag discharge port block 22. Thereafter, the molten slag 20 flows through the slag discharge groove 22d into the slag discharge port 17, and falls down through the slag discharge port 17. Thus, the molten slag 20 is prevented from being adhered to the surface of the slag discharge port block 22 and being solidified thereon. The number of the slag discharge grooves 22d may be one or plural.

[0052] On the other hand, the combustion gas 16 which has flowed into the upper surface 22a at the upstream side of the slag discharge port block 22 moves toward the slag discharge port 17 in an upward flow (see FIG. 9A). Thus, the combustion gas 16 flows through a location above the slag discharge port 17, and hence the combustion gas 16 is prevented from flowing into the slag discharge port 17. Further, because the upper surface of the slag discharge port block is formed into a slant surface which is inclined downwardly toward the outer periphery of the slag discharge port block, molten slag attached to the upper surface is entirely collected at the outer circumferential portion of the slag discharge port block, and molten slag flowing downwardly on the inner wall surface of the slagging combustion furnace is collected at the outer circumferential portion of the slag discharge port block. Then, the molten slag flows through the slag discharge groove 22d into the slag discharge port 17, and falls down through the slag discharge port 17. Thus, the molten slag is prevented from being adhered to the surface of the slag discharge port block and being solidified thereon.

[0053] Further, the slag discharge port block 22 is produced in advance from refractory material through a forming process and a drying process as a precast block in a plant. Thus, it is possible to employ refractory material (for example, high chromium refractory material containing chromium of 60% or more) which is resistant to a thermal wear and a high temperature. Further, if the slag discharge port block 22 comprises a plurality of block pieces, which have been produced through the above forming process and drying process, then production of the block pieces, and transportation of the block pieces are facilitated, and only damaged or broken block pieces can be replaced. Although the slag discharge port block 22 comprises a circular disk in the above embodiment, the slag discharge port block 22 may comprise an elliptical disk or a rectangular parallelepiped so as to fit the structure of the slagging combustion furnace 10.

[0054] FIG. 10 is a view showing a slag discharge port of a slagging combustion furnace according to another embodiment of the present invention. As shown in FIG. 10, a slag discharge port 17 is provided at the furnace bottom between the secondary combustion chamber 12 and the tertiary combustion chamber 13 of the slagging combustion furnace 10 . The upper surface 17b of the furnace bottom at an outer circumferential portion around the slag discharge port 17 is formed into a slant surfacewhich is inclined downwardly toward the slag discharge port 17, and the height h_1 of the inner wall surface of the slag discharge port 17 at the upstream side of a flow of the combustion gas 16 is higher than the height h_2 of the inner wall surface of the slag discharge port 17 at the downstream side of the flow of the combustion gas 16 ($h_1>h_2$).

[0055] FIG. 11 is an enlarged view showing an essential part of FIG. 10. As shown in FIG. 11, an inclination angle α of the upper surface 17b at the upstream side of the flow of the combustion gas 16, the height h_1 of the innerwall surface of the slag discharge port 17 at the upstream side of the flow of the combustion gas 16, and the height h_2 at the downstream side of the flow of the combustion gas 16 are set such that the combustion gas 16 flowing on the upper surface 17b at the upstream side of the slag discharge port 17 passes through a location above the slag discharge port 17, and reaches the upper surface 17b at the downstream side of the slag discharge port 17.

[0056] Because the inclination angle α of the upper surface 17b at the upstream side of the slag discharge port 17, the height h_1 of the inner wall surface of the slag discharge port 17 at the upstream side, and the height h_2 at the downstream side are set in the above-described manner, the combustion gas 16 which has flowed into the upper surface 17b at the upstream side of the slag discharge port 17 passes though a location above the slag discharge port 17 in a smooth stream without generating a turbulent flow at the location near the slag discharge port 17. Therefore, the flow of the combustion gas 16 does not affect adversely the discharge state of the molten slag 20 flowing into the slag discharge port 17. Further, the combustion gas 16 can be prevented from being discharged through the slag discharge port 17 to the outside of the furnace.

[0057] FIG. 12 is a view showing a slag discharge port and its vicinity of a slagging combustion furnace according to the present invention. FIG. 13A is a cross-sectional view showing the slag discharge port shown in FIG. 12, and FIG. 13B is a plan view showing the slag discharge port shown in FIG. 12. The upper surface 17b of the furnace bottom at an outer circumferential portion around the slag discharge port 17 is formed into a slant surface which is inclined upwardly toward the slag discharge port 17. A slag discharge groove 17d extending from an outer periphery at the upstream side of a flow of the combustion gas to the slag discharge port 17 is formed in the upper surface 17b.

[0058] As described above, since the upper surface 17b at the radially outer side of the slag discharge port 17 is formed into the slant surface which is inclined upwardly toward the slag discharge port 17, the combustion gas 16 which has flowed into the upper surface 17b at the upstream side of the slag discharge port 17 moves toward the slag discharge port 17 in an upward flow as shown in FIG. 13A. Thus, the combustion gas 16 flows through a location above the slag discharge port 17, and hence the combustion gas 16 is prevented from flowing into the slag discharge port 17. Further, because the upper surface 17b at the outer circumferential portion around slag discharge port 17 is formed into the slant surface which is inclined upwardly toward the slag discharge port 17, molten slag 20 attached to the upper surface is entirely collected at the radially outer side of the slag discharge port 17, and molten slag flowing downwardly on the inner wall surface of the slagging combustion furnace is collected at the radially outer side of the slag discharge port 17. Thus, the molten slag 20 is prevented from being adhered to the upper surface 17b and being solidified thereon.

[0059] Further, in the case where a gasification and slagging combustion system according to the present invention comprises a gasification furnace for gasifying wastes to produce a gas containing ash and unburned carbon, and the slagging combustion furnace having the above structure, the gasification furnace may comprise an internal circulating fluidized-bed gasification furnace, an external circulating fluidized-bed gasification furnace, a kiln furnace, or the like.

[0060] Although the swirling-type slagging combustion furnace has been described as a slagging combustion furnace, in the case where the present invention is characterized by the height of the slag discharge port and/or the inclination angle of the upper surface around the slag discharge port to prevent clogging of the slag discharge port of the slagging combustion furnace, the slagging combustion furnace is not limited to the swirling-type slagging combustion furnace, and may be any type of slagging combustion furnace.

[0061] FIG. 14 is a view showing a slagging combustion furnace according to another embodiment of the present invention. A slag discharge port block 32 is disposed at the lowermost position of the secondary combustion chamber, and a slag discharge groove 32d is formed in the slag discharge port block 32 only at the primary combustion chamber 11 side. FIGS. 15A through 15C show the slag discharge port block, and FIG. 15A is a perspective view of the slag discharge port, FIG. 15B is a cross-sectional view taken along line XV_B-XV_B of FIG. 15A, and FIG. 15C is a cross-sectional view taken along line XV_C-XV_C of FIG. 15A. As shown in FIGS. 15A through 15C, the slag discharge port block 32 has the slag discharge groove 32d which faces the primary combustion chamber 11. The slag discharge port block 32 is disposed at the bottomportion of the secondary combustion chamber 12 which is an end portion of the primary combustion chamber 11.

[0062] With this arrangement, as shown in FIG. 15A, molten slag 20 which has flowed on the inner wall surface of the slagging combustion furnace 10 is collected at the location around the slag discharge port block 32, and then is discharged from the slag discharge groove 32d. Because the discharge of molten slag is concentratedly carried out by the slag discharge groove 32d, the molten slag is prevented from being cooled. Further, since the slag discharge groove 32d is formed at the upstream side (the primary combustion chamber side) of a flow of the combustion gas 16, part of the combustion gas 16 flows through the slag discharge groove 32d, thus keeping the molten slag 20 at a high temperature.

[0063] FIG. 16 is a view showing a detailed structure of the embodiment. FIGS. 17A and 17B are cross-sectional views showing the manner in which molten slag flows through the slag discharge port. As shown in FIGS. 14 and 16, a line 40 is provided to connect a slag discharge chute 30 and the tertiary combustion chamber 13, and a dust collector 41 and a fan 42 are provided in the line 40. The slag discharge chute 30 constitutes a'water quenching trough which cools molten slag 20 discharged through the slag discharge port by slag cooling water to form water-quenched slag. With the above arrangement, steam generated by cooling of molten slag and solidification of the slag is drawn from the slag discharge chute 30 by the fan 42, and the combustion gas 16 which has passed through the slag discharge port 17 is drawn by the fan 42, thus forming a mixed gas. The mixed gas is fed to the tertiary combustion chamber 13. With this arrangement, the molten slag can be smoothly discharged through the slag discharge port 17 to the slag discharge chute 30 and then a water reservoir 43 as shown in FIGS. 16 and 17A.

[0064] The supply position of the mixed gas which is drawn from the slag discharge chute and is supplied to the slagging combustion furnace 10 is not limited to the tertiary combustion chamber 13. Specifically, the line 40 can be constructed such that the line 40 connects the slag discharge chute and at least one of a duct connecting the gasification furnace and the slagging combustion furnace, the primary combustion chamber, the secondary combustion chamber, the tertiary combustion chamber, and a flue provided upstream of a waste heat boiler. In this case, the dust collector 41 and the fan 42 are provided in the line 40, and a warm-up device may be further provided. With this arrangement, the slag discharge port 17 can be prevented from clogging and the molten slag can be smoothly discharged through the slag discharge port 17 to the slag discharge chute 30 and then the water reservoir 43 as shown in FIGS. 16 and 17A. With this arrangement, even if the mixed gas contains unburned carbon and the like, such unburned carbon and the like can be combusted and treated, and hence the mixed gas can be properly treated. In the case where the warm-up device is provided in the line 40, it is desirable that the mixed gas is warmed up to a temperature of about 200°C or higher, preferably about 300°C or higher so as not to cause a remarkable temperature drop in the slagging combustion furnace, even if the mixed gas is supplied to the slagging combustion furnace.

[0065] Even if the above arrangement is employed, when the system is operated for a long period of time, as shown in FIG. 14, even if the molten slag is prevented frombeing rapidly cooled locally, the molten slag is attached to the slag discharge port and its vicinity of the slag discharge block 32 or the like to form aggregated slag 21, and thus the slag discharge port 17 may be clogged with the slag (see FIG. 17B). If this clogging of the slag discharge port occurs, the molten slag cannot be discharged through the slag discharge port. Further, when the system is operated for a long period of time, even if the slag discharge function is not completely lost, the slag discharge port tends to be clogged with the slag adhesion and solidification. Thus, it is important to avoid an inclination of clogging of the slag discharge port because if there is an indication of decreasing an opening area of the slag discharge port, the clogging of the slag discharge port rapidly progresses due to the following vicious circle. Specifically, the vicious circle is as follows: As the opening area of the slag discharge port is reduced, draft resistance (pressure loss) of the combustion gas 16 which passes through the slag discharge port is increased. Thus, the amount of combustion gas to be drawn is lowered, it is difficult to keep the molten slag at a high temperature, and hence the opening area of the slag discharge port is further reduced. Therefore, an inclination of clogging of the slag discharge port has to be avoided. Thus, it is extremely important to prevent the above problems from occurring for the purpose of ensuring the slag discharge function for discharging molten slag smoothly through the slag discharge port.

[0066] In order to achieve the above object, in an embodiment shown in FIG. 18, the pressure differential between the interior of the slag discharge chute 30 and the interior of the secondary combustion chamber 12 is detected by the pressure instrument 45, and if the pressure differential exceeds a set value, an inclination of clogging of the slag discharge port is judged, and the slag discharge port and a portion around the slag discharge port are heated by a secondary combustion chamber burner 46. For example, a signal indicative of a pressure differential measured by the pressure instrument 45 is sent to a controller (not shown) through a first signal transmitting means. The controller judges whether the pressure differential is equal to or larger than a set value, and if the pressure differential is equal to or larger than the set value, then the controller sends a starting signal for starting the secondary combustion chamber burner 46 to the secondary combustion chamber burner 46 through a second signal transmitting means. This arrangement can prevent the slag discharge port and a portion around the slag discharge port from being clogged.

[0067] According to the present invention, the following excellent effects can be obtained.

(1) Because a slag discharge port is formed by a replaceable slag discharge port block which is a distinct member different from a furnace wall, the slag discharge port block can be produced in advance using refractory material having a high resistance to a thermal wear and a high temperature through a predetermined manufacturing process (for example, a forming process and a drying process) in a plant. Thus, the newly produced slag discharge port block is carried into the site where the slagging combustion furnace is placed, and the slag discharge port block which has been damaged by melting or broken for some cause can be easily replaced with the newly produced slag discharge port block. Further, since the slag discharge port block is composed of refractory material (for example, high chromium refractory material) which is resistant to a thermal wear and a high temperature, the inner wall of the slag discharge port can be prevented from being damaged by melting or being broken. Further, since the slag discharge port is formed by the slag discharge port block, the slag discharge port is not cooled excessively by water tubes, unlike a conventional discharge port, thus preventing molten slag from being adhered or being solidified.

(2) Because a slag discharge groove extending from an outer periphery of the slag discharge port block at an upstream side of a combustion gas passage to the slag discharge port is formed in an upper surface of the slag discharge port block, molten slag flowing downwardly on the inner wall surface of the slagging combustion furnace flows through the slag discharge groove into the slag discharge port, and falls down through the slag discharge port. Thus, the discharge position of the molten slag is fixed. Further, since the molten slag flows concentratedly, even if the scale of system or operational condition of the system is such that the amount of slag to be generated is small, the molten slag is less susceptible to being cooled. Thus, the molten slag is prevented from being adhered to the surface of the slag discharge port block or being solidified thereon.

(3) Because the upper surface of the slag discharge port block is formed into a slant surface which is inclined downwardly toward the slag discharge port, and the height of the inner wall of the slag discharge port at the upstream side of a flow of the combustion gas is higher than the height of the inner wall of the slag discharge port at the downstream side of the flow of the combustion gas, the combustion gas which has flowed into the upper surface of the slag discharge port block at the upstream side of the flow of the combustion gas passes through a location above the slag discharge port, and flows along the upper surface of the slag discharge port at the downstream side of the slag discharge port. Thus, since the combustion gas does not collide with the inner wall surface of the slag discharge port, the combustion gas can be prevented from flowing into

the slag discharge port. Further, the gas stream near the slag discharge port is smoothed, and hence a fall position of the discharged molten slag is not deviated.

(4) Because the upper surface of the slag discharge port block is formed into a slant surface which is inclined downwardly toward the outer periphery of the slag discharge port block, the combustion gas which has flowed into the upper surface of the slag discharge port block at the upstream side of the flow of the combustion gas moves toward the slag discharge port in an upward flow. Thus, the combustion gas is prevented from flowing into the slag discharge port. Further, because the upper surface of the slag discharge port block is formed into the slant surface which is inclined downwardly toward the outer periphery of the slag discharge port block, molten slag attached to the upper surface is entirely collected at the outer circumferential portion of the slag discharge port block, and molten slag flowing downwardly on the inner wall surface of the slagging combustion furnace is collected at the outer circumferential portion of the slag discharge port block. Then, the molten slag flows through the slag discharge groove into the slag discharge port. Thus, the molten slag is prevented from being adhered to the surface of the slag discharge port block or being solidified thereon.

(5) Since the slag discharge port block is composed of a plurality of block pieces, the slag discharge port block can be easily produced and can be easily transported. Further, even if the slag discharge port block is damaged or broken, only the block piece which has been damaged or broken can be replaced. Thus, the replacement of the block piece is facilitated.

(6) As a slagging combustion furnace of a gasification and slagging combustion system, by using any of the above slagging combustion furnaces, the slagging combustion furnace which exhibits the above features can be constructed.

(7) Because the height of the inner wall of the slag discharge port at the upstream side of the flow of the combustion gas is higher than the height of the inner wall of the slag discharge port at the downstream side of the flow of the combustion gas, the combustion gas which has flowed along the upper surface at the upstream side of the slag discharge port passes through a location above the slag discharge port, and reaches the upper surface at the downstream side of the slag discharge port. Thus, since the combustion gas flows smoothly without causing the combustion gas to collide with the inner wall of the slag discharge port and without generating a turbulent flow at the location near the slag discharge port, the flow of the combustion gas does not affect adversely the discharge state of the molten slag.

(8) Because the combustion gas passes through a location above the slag discharge port, and a flow direction of the combustion gas is changed by the upper surface at the downstream side of the slag discharge port, the amount of the combustion gas flowing into the slag discharge port can be greatly reduced.

(9) Because the upper surface at an outer circumferential portion around the slag discharge port is formed into a slant surface which is inclined upwardly toward the slag discharge port, and the height of the inner wall of the slag discharge port and the inclination angle of the slant surface at the upstream side of the flow of the combustion gas are set such that the combustion gas flowing along the slant surface at the upstream side reaches the slant surface at the downstream side, the combustion gas which has flowed into the upper surface at the upstream side of the slag discharge port passes through a location above the slag discharge port, and reaches the upper surface at the downstream side of the slag discharge port without causing the combustion gas to collide with the inner wall of the slag discharge port and without generating a turbulent flow at the location near the slag discharge port, the combustion gas flow smoothly and the flow of the combustion gas does not affect adversely the discharge state of the molten slag.

(10) Because the upper surface at an outer circumferential portion around the slag discharge port is formed into a slant surface which is inclined upwardly toward the slag discharge port, the combustion gas which has flowed into the upper surface at the upstream side of the slag discharge port moves toward the slag discharge port in an upward flow. Thus, the combustion gas is prevented from flowing into the slag discharge port.

(11) Because a slag discharge groove extending from a slant surface at the upstream side of the flow of the combustion gas to the slag discharge port is formed in the upper surface at an outer circumferential portion around the slag discharge port, molten slag flowing downwardly on the inner wall of the slagging combustion furnace flows through the slag discharge groove into the slag discharge port. Thus, the discharge position of the molten slag is fixed.

(12) Because molten slag flows concentratedly through a slag discharge groove, even if the scale of system or operational condition of the system is such that the amount of slag to be generated is small, the molten slag is less susceptible to being cooled. Thus, the molten slag is prevented from being adhered to the surface of the radially outer portion of the slag discharge port or being solidified thereon.

(13) Because a slag discharge groove is formed only at the primary combustion chamber side, the slag is concentratedly discharged through the slag dis-

charge groove to prevent the molten slag from being cooled.

(14) Because the combustion gas which has passed through the slag discharge port is drawn together with steam generated by cooling of slag and solidification of the slag, the slag discharge port and a portion around the slag discharge port can be prevented from being cooled by the steam, and can be kept at a high temperature.

(15) A pressure differential between the interior of the slag discharge chute and the interior of the secondary combustion chamber is detected, and if the pressure differential exceeds a set value, then an inclination of clogging of the slag discharge port by attachment of slag and solidification of the slag is judged, and the slag discharge port and a portion around the slag discharge port are heatedby a secondary combustion chamber burner to prevent the slag discharge port from being clogged.

Industrial Applicability

[0068] The present invention is applicable to a slagging combustion furnace and a gasification and slagging combustion system for being supplied with a gas produced in a gasification furnace or the like and containing ash and unburned carbon, and combusting the supplied gas at a high temperature to melt ash into molten slag.

Claims

1. A slagging combustion furnace comprising:

a combustion chamber for combusting a combustible gas containing ash and melting said ash; and
a slag discharge port for discharging molten slag produced by melting said ash;

wherein said slag discharge port is formed by refractory material which is replaceable.

2. A slagging combustion furnace according to claim 1, wherein said slag discharge port comprises an opening formed at a central portion of a slag discharge port block, and at least one slag discharge groove extending from an outer peripheral portion of said slag discharge port block at the upstream side of a flow of combustion gas to said slag discharge port is formed in an upper surface of said slag discharge port block.

3. A slagging combustion furnace according to claim 2, wherein said upper surface of said slag discharge port block is a slant surface which is inclined downwardly toward said slag discharge port, and an upper end of an outer wall forming said slag discharge port at the upstream side of said flow of said combustion gas is higher than an upper end of said inner wall forming said slag discharge port at the downstream side of said flow of said combustion gas.

4. A slagging combustion furnace according to claim 2, wherein said upper surface of said slag discharge port block is a slant surface which is inclined downwardly toward an outer circumferential portion of said slag discharge port block.

5. A slagging combustion furnace according to any one of claims 1 through 4, wherein said slag discharge port block comprises a plurality of block pieces.

6. A gasification and slagging combustion system, comprising:

a gasification furnace for gasifying wastes to produce a combustible gas containing ash and unburned carbon; and
a slagging combustion furnace for combusting said combustible gas containing said ash and said unburned carbon and melting said ash;

wherein said slagging combustion furnace comprises a slagging combustion furnace according to any one of claims 1 through 5.

7. A slagging combustion furnace comprising:

a combustion chamber for combusting a combustible gas containing ash and melting said ash; and
a slag discharge port for discharging molten slag produced by melting said ash;

wherein the height of an inner wall forming said slag discharge port is higher at the upstream side of a flowof combustion gas than at the downstream side of said flow of said combustion gas.

8. A slagging combustion furnace according to claim 7, wherein an upper surface at an outer circumferential portion around said slag discharge port is a slant surface inclined upwardly toward said slag discharge port, and at least one slag discharge groove extending to said slag discharge port is formed in said slant surface at the upstream side of said flow of said combustion gas.

9. A waste treatment method comprising:

gasifying wastes to produce a combustible gas containing ash in a fluidized-bed furnace;
combusting said combustible gas and melting said ash to form molten slag in a slagging com-

bustion furnace, said slagging combustion furnace comprising a primary combustion chamber, a secondary combustion chamber and a tertiary combustion chamber;
trapping said molten slag on an inner wall surface of said primary combustion chamber and flowing said trapped molten slag downwardly into said secondary combustion chamber;
flowing said molten slag on said inner wall surface of said secondary combustion chamber and discharging said molten slag through a slag discharge groove formed in a slag discharge port block to a slag discharge port formed in said slag discharge port block, said slag discharge port blockbeing disposed at a lowermost part of said secondary combustion chamber, said slag discharge groove being formed at said primary combustion chamber side;
trapping molten slag on an inner wall surface of said tertiary combustion chamber from combustion gas introduced into said tertiary combustion chamber, and then discharging said trapped molten slag through said slag discharge groove to said slag discharge port block; and
supplying said molten slag discharged from said slag discharge groove to a water quenching trough and cooling said discharged molten slag in said water quenching trough.

10. A waste treatment method comprising:

gasifying wastes to produce a combustible gas containing ash in a fluidized-bed furnace;
combusting said combustible gas and melting said ash to form molten slag in a slagging combustion furnace, said slagging combustion furnace comprising a primary combustion chamber, a secondary combustion chamber and a tertiary combustion chamber;
trapping said molten slag on a wall surface of said primary combustion chamber and flowing said trapped moltenslag downwardly into said secondary combustion chamber;
flowing said molten slag on said wall surface of said secondary combustion chamber to a slag discharge groove and discharging said molten slag through said slag discharge groove, a slag discharge port block disposed at a lowermost part of said secondary combustion chamber having said slag discharge groove at said primary combustion chamber side;
trapping molten slag on a wall surface of said tertiary combustion chamber from combustion gas introduced into said tertiary combustion chamber, and then discharging said trapped molten slag through said slag discharge groove to said slag discharge port;
cooling and solidifying said molten slag discharged from said slag discharge groove; and
drawing steam generated by said cooling and solidifying of said molten slag and combustion gas through said slag discharge port of said secondary combustion chamber to form a mixed gas, and introducing said mixed gas to said tertiary combustion chamber.

11. A waste treatment method comprising:

gasifying wastes to produce a combustible gas containing ash in a fluidized-bed furnace;
combusting said combustible gas and melting said ash to form molten slag in a slagging combustion furnace, said slagging combustion furnace comprising a primary combustion chamber, a secondary combustion chamber and a tertiary combustion chamber;
trapping said molten slag on a wall surface of said primary combustion chamber and flowing said trapped moltenslag downwardly into said secondary combustion chamber;
flowing said molten slag on said wall surface of said secondary combustion chamber to a slag discharge groove and discharging said molten slag through said slag discharge groove, a slag discharge port block disposed at a lowermost part of said secondary combustion chamber having said slag discharge groove at said primary combustion chamber side;
trapping molten slag on a wall surface of said tertiary combustion chamber from combustion gas introduced into said tertiary combustion chamber, and then flowing said molten slag on said wall surface of said tertiary combustion chamber to said slag discharge port block and discharging saidmolten slag through said slag discharge groove;
cooling said molten slag discharged through said slag discharge groove in a slag discharge chute; and
detecting a pressure differential between an interior of said secondary combustion chamber and an interior of said slag discharge chute;

wherein when saidpressure differential exceeds a set value, a secondary combustion chamber burner provided at said secondary combustion chamber is operated to heat a portion around said slag discharge port.

12. A waste treatment apparatus comprising:

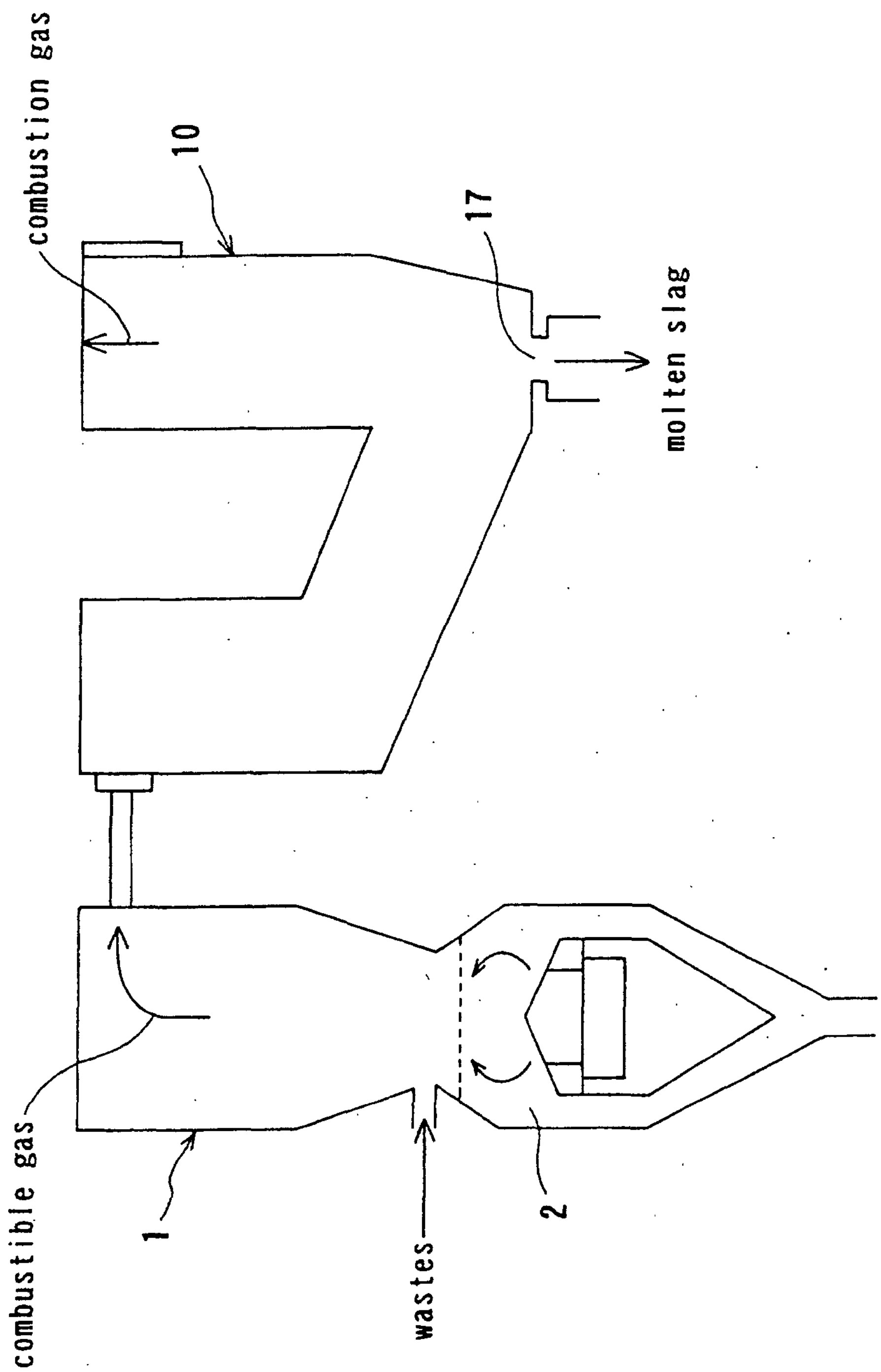
a fluidized-bed furnace for gasifying wastes to produce a combustible gas containing ash;
a slagging combustion furnace for combusting said combustible gas and melting said ash to

form molten slag, said slagging combustion furnace comprising a primary combustion chamber, a secondary combustion chamber, a tertiary combustion chamber, and a slag discharge port block at a lowermost part of said secondary chamber and having a slag discharge groove at said primary combustion chamber side; wherein said molten slag is trapped on a wall surface of said primary combustion chamber and said trapped molten slag flows downwardly into said secondary combustion chamber, said molten slag flows on said wall surface of said secondary combustion chamber to said slag discharge groove and is discharged from said slag discharge groove, molten slag is trapped on a wall surface of said tertiary combustion chamber from combustion gas introduced into said tertiary combustion chamber, and then said trapped molten slag flows downwardly to said slag discharge port block and is discharged from said slag discharge groove;

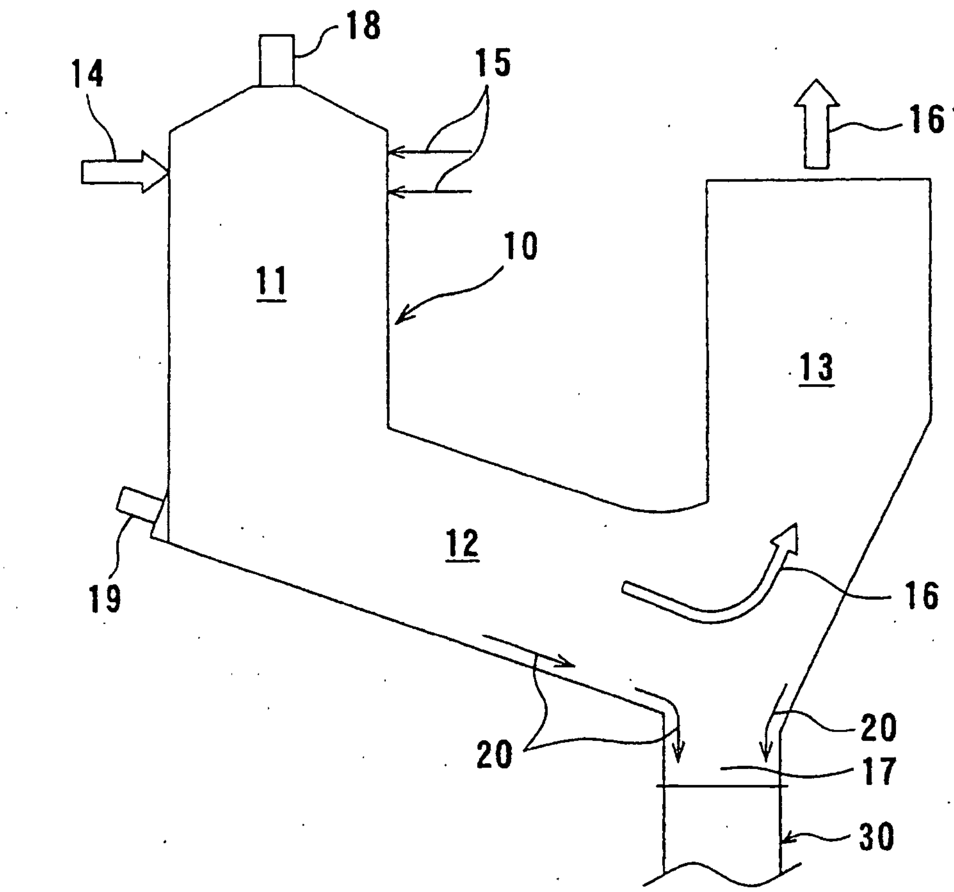
a slag discharge chute disposed below said slag discharge port block for cooling said molten slag discharged from said slag discharge groove; and

a pressure instrument for detecting a pressure differential between an interior of said secondary combustion chamber and an interior of said slag discharge chute; wherein when said pressure differential between the interior of said secondary combustion chamber and the interior of said slag discharge chute exceeds a set value, a secondary combustion chamber burner provided at said secondary combustion chamber is operated to heat a portion around said slag discharge port.

FIG. 1



F I G. 2



F I G. 3

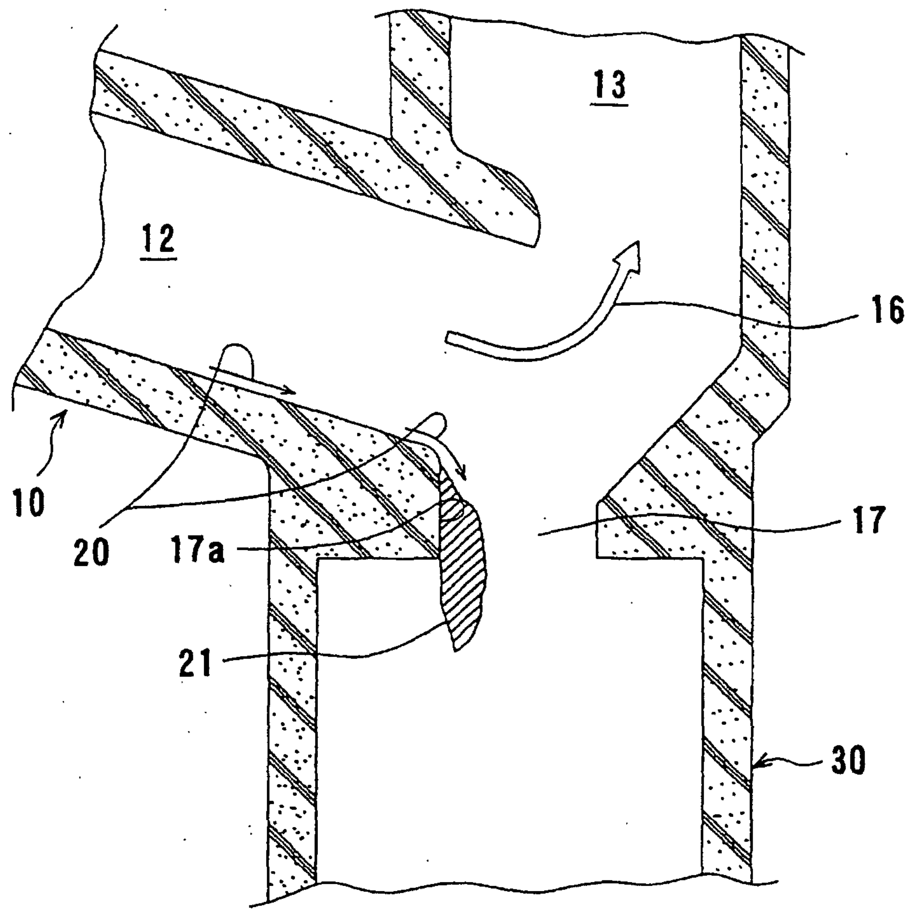
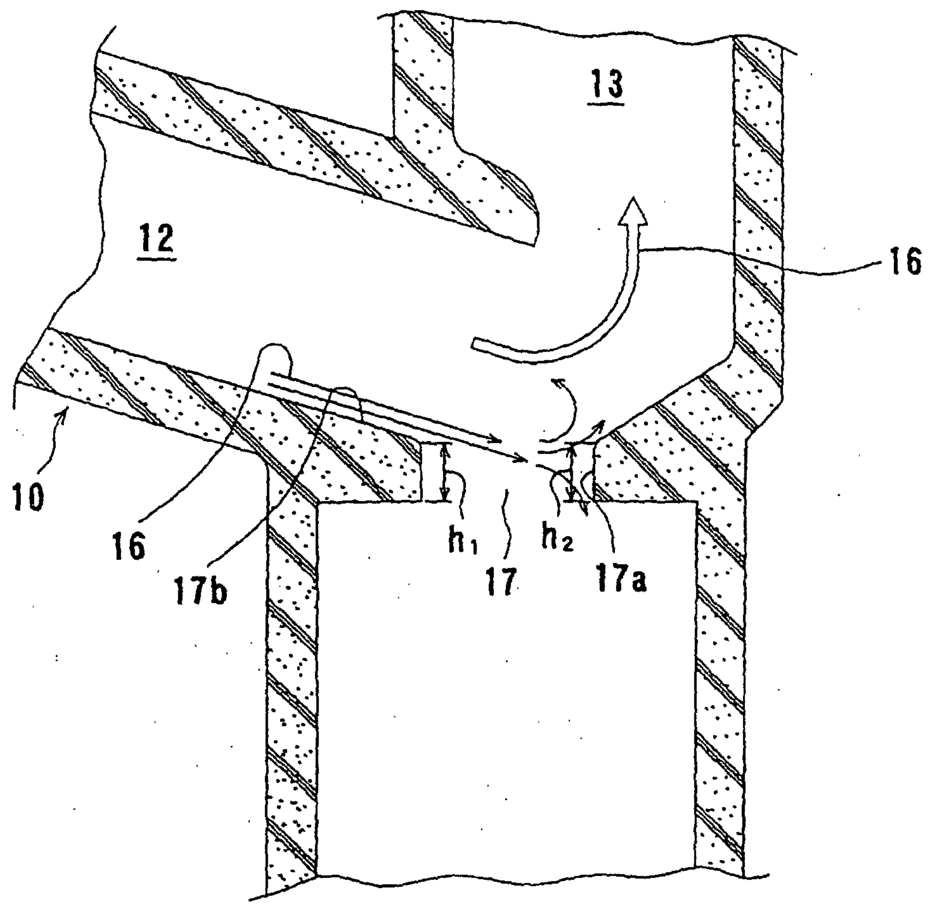


FIG. 4



F I G. 5

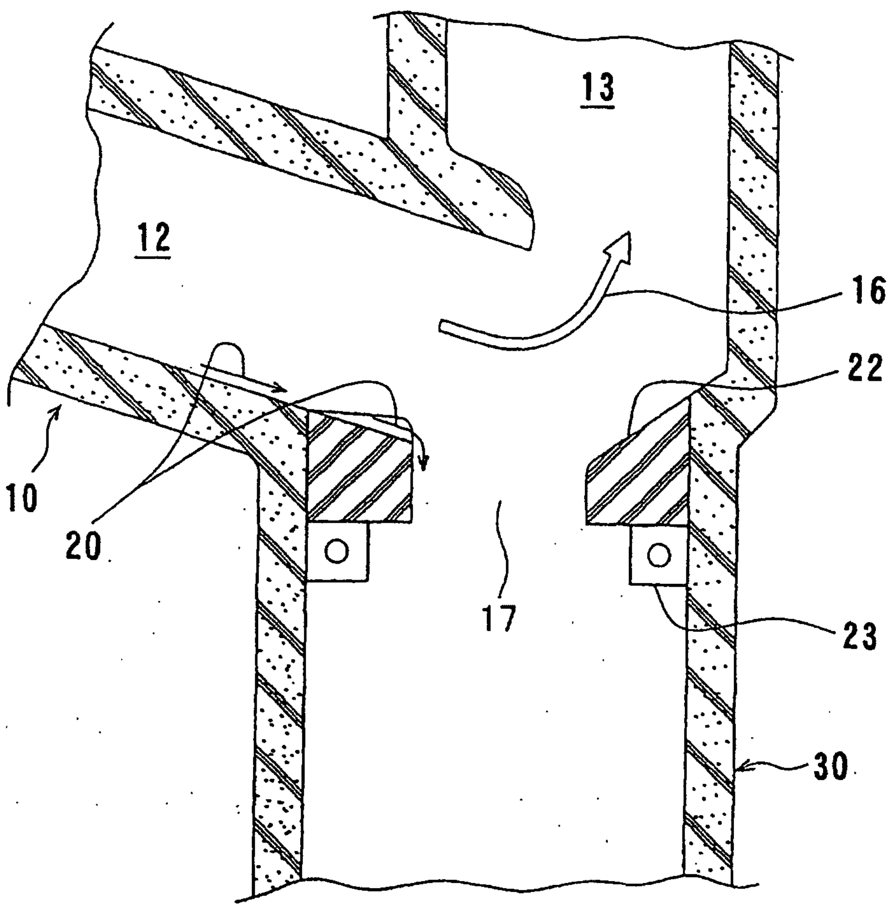


FIG. 6A

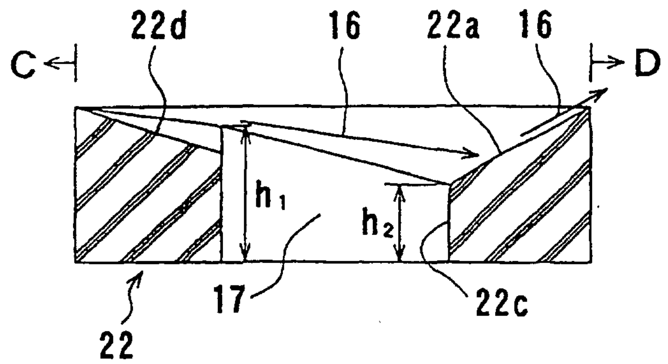


FIG. 6B

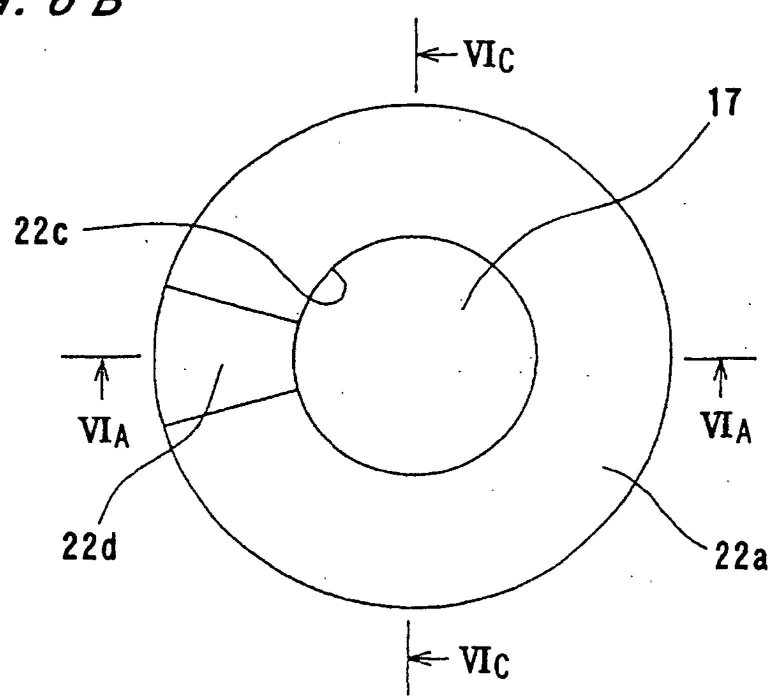
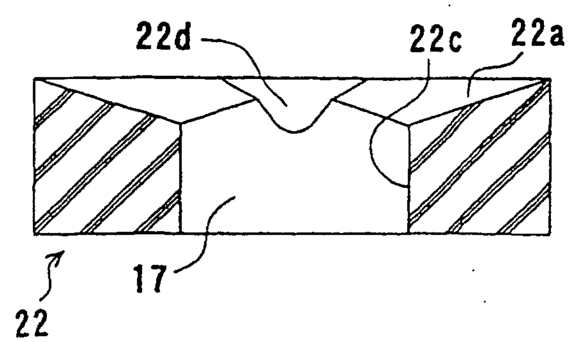
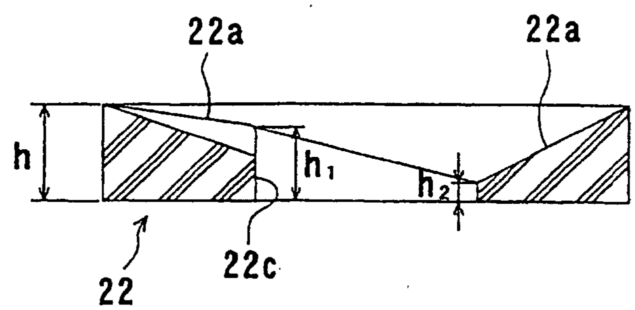


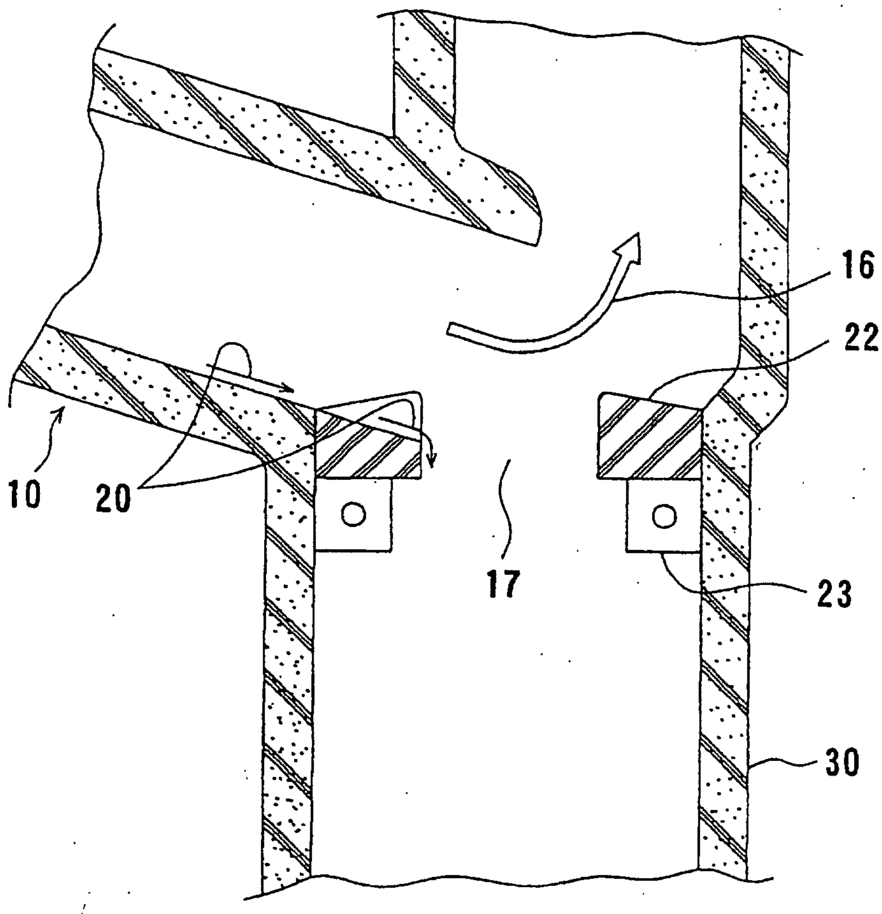
FIG. 6C



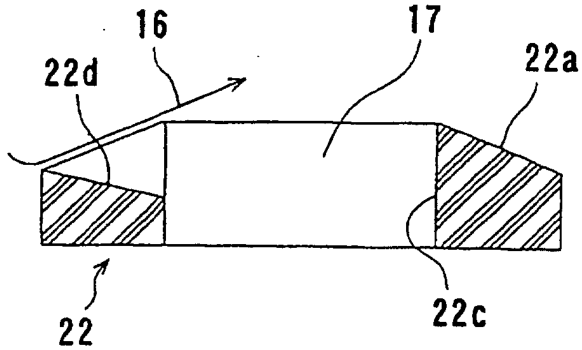
F I G. 7



F I G. 8



F I G. 9A



F I G. 9B

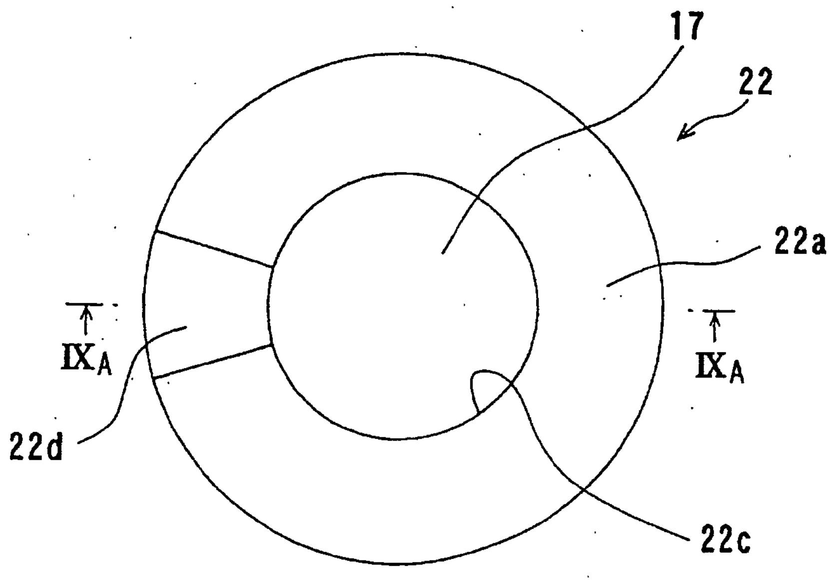


FIG. 10

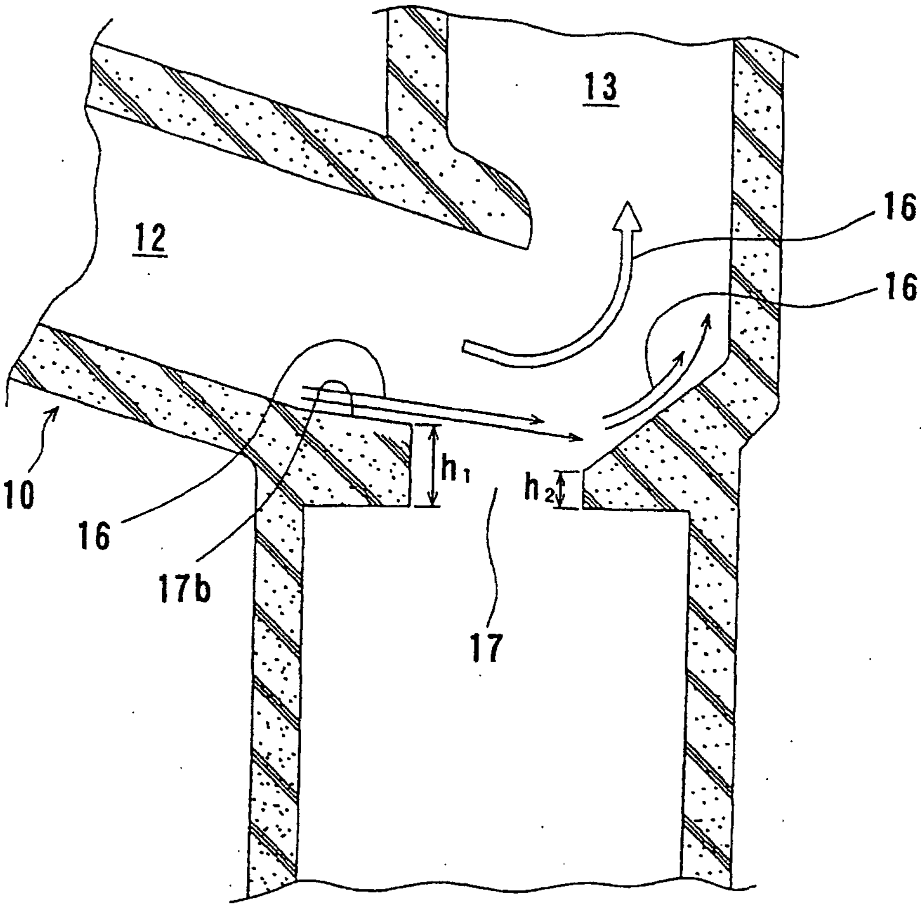


FIG. 11

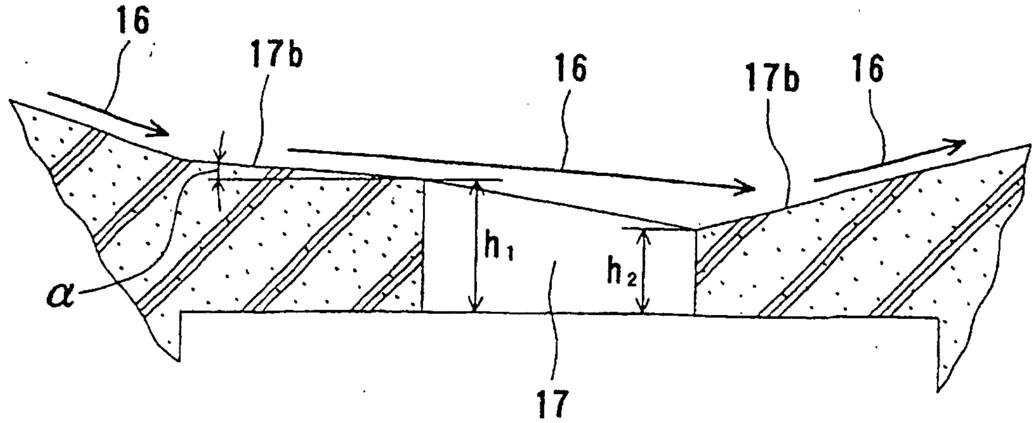


FIG. 12

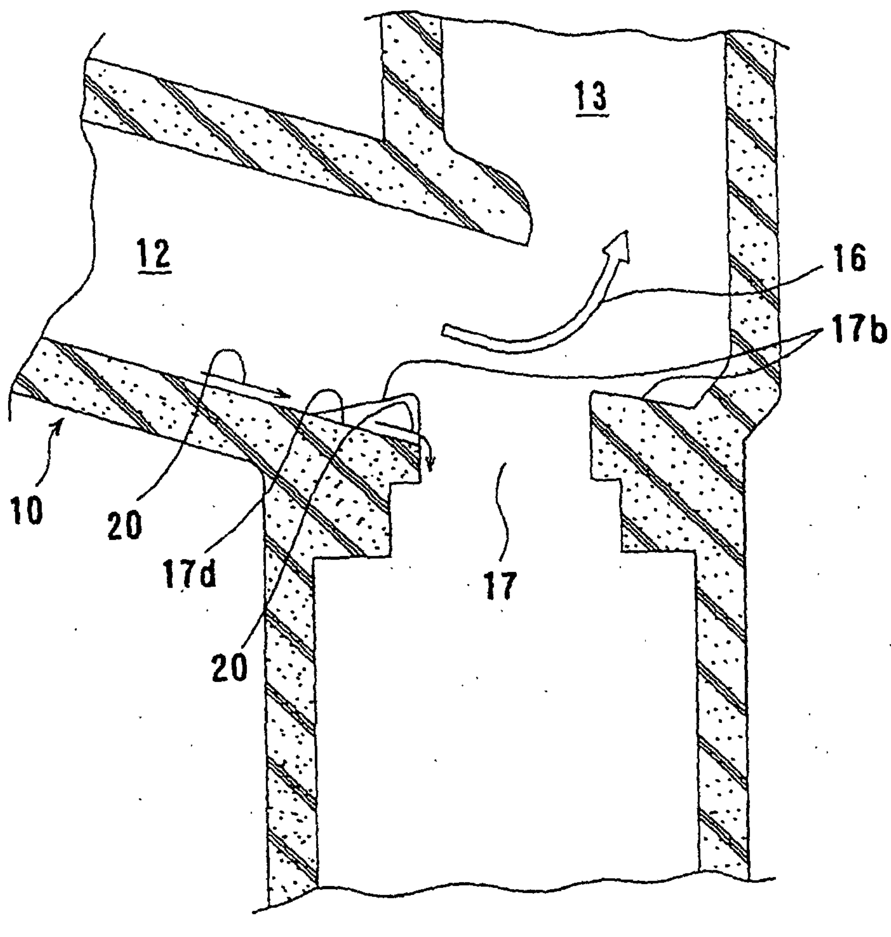


FIG. 13A

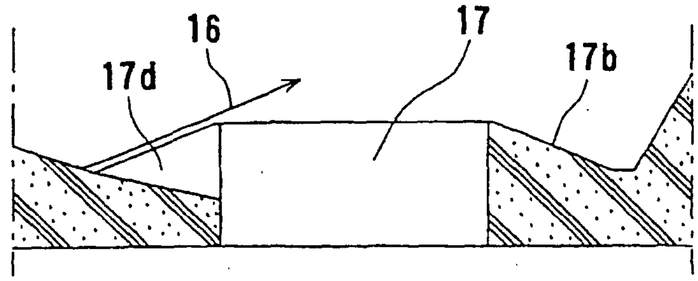


FIG. 13B

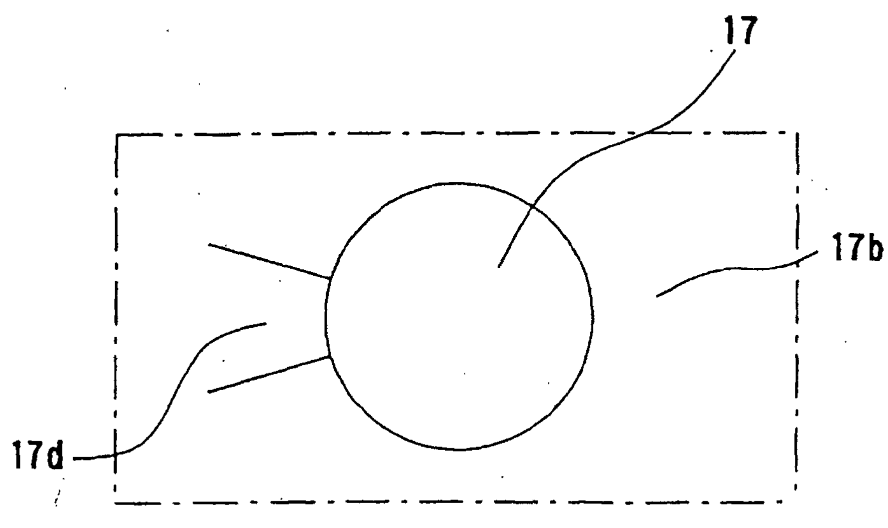


FIG. 14

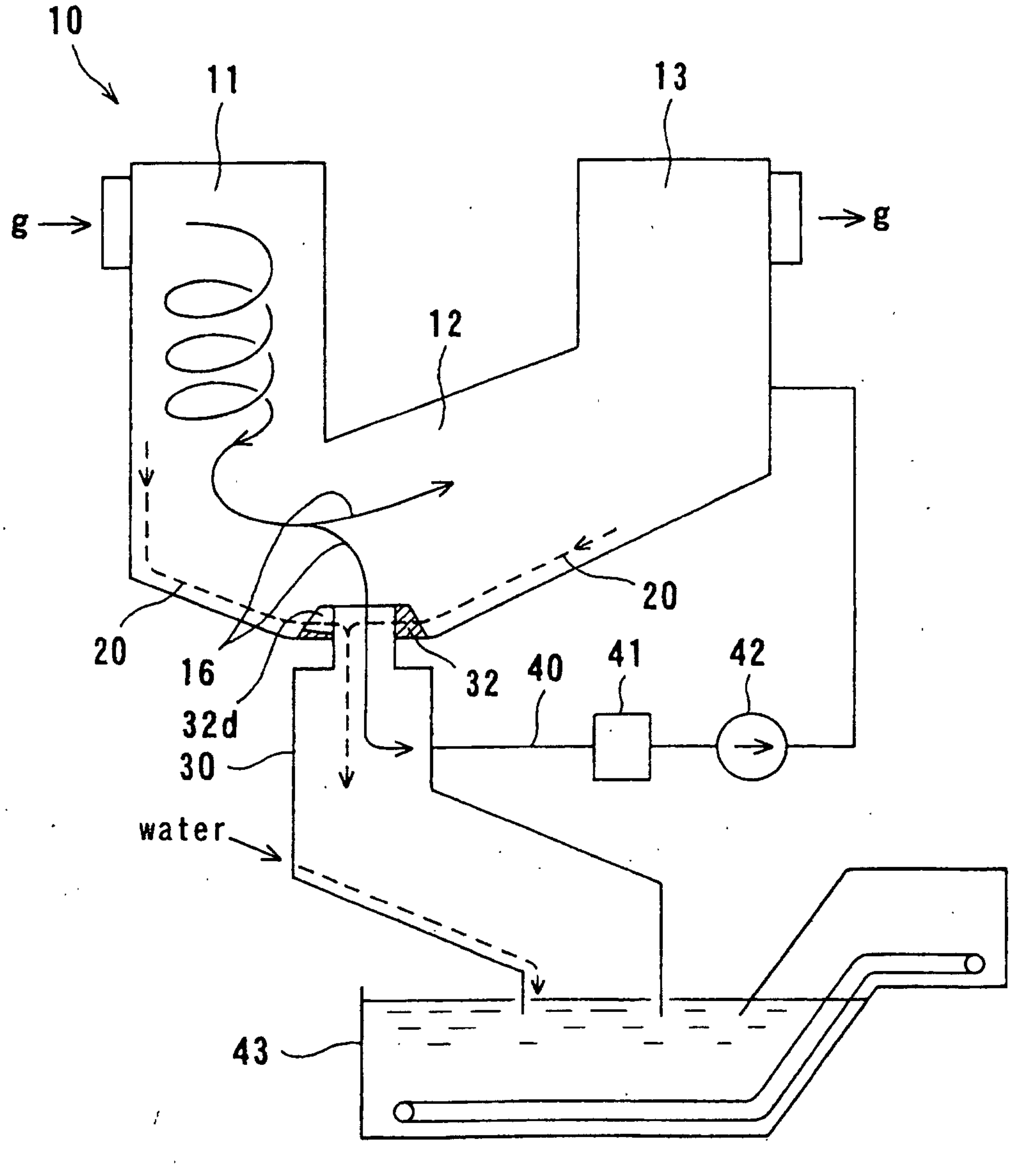


FIG. 15A

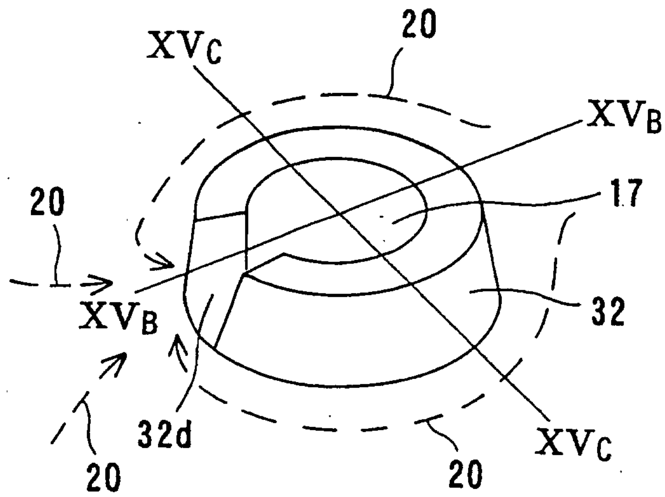


FIG. 15B

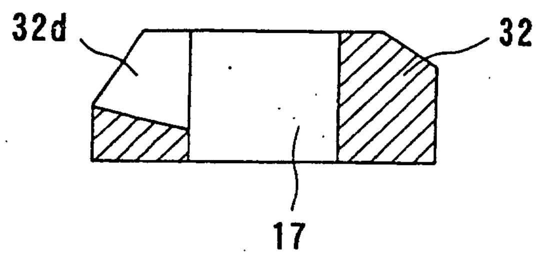


FIG. 15C

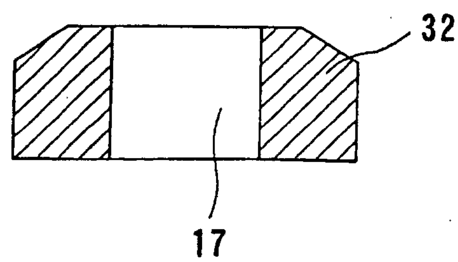


FIG. 16

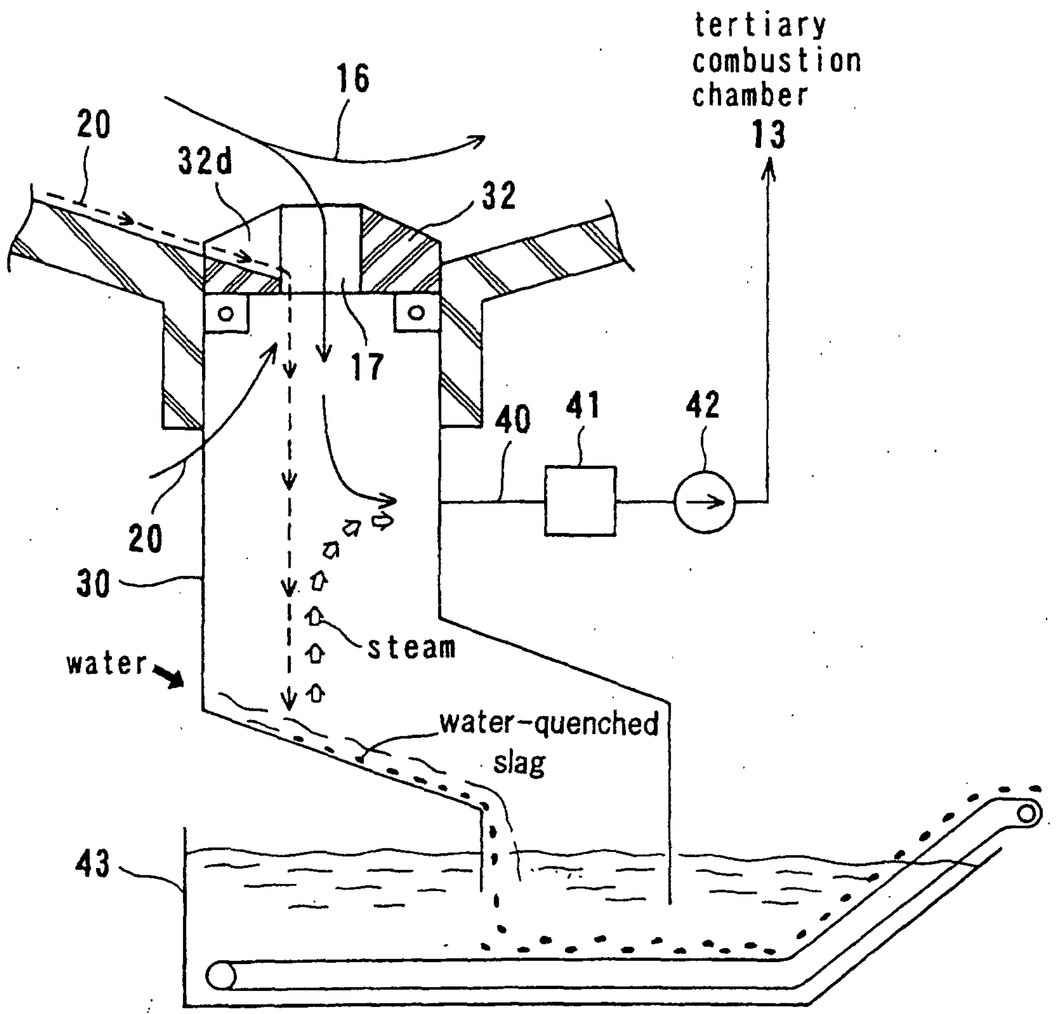

tertiary
combustion
chamber
13
16
20
32d
32
17
40
41
42
20
30
steam
water
water-quenched
slag
43

FIG. 17A

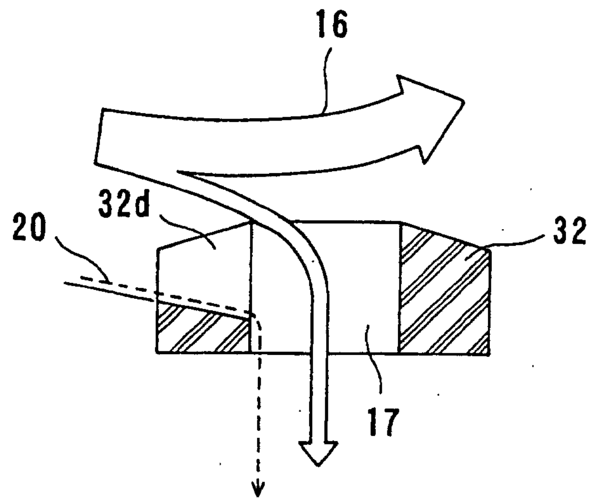


FIG. 17B

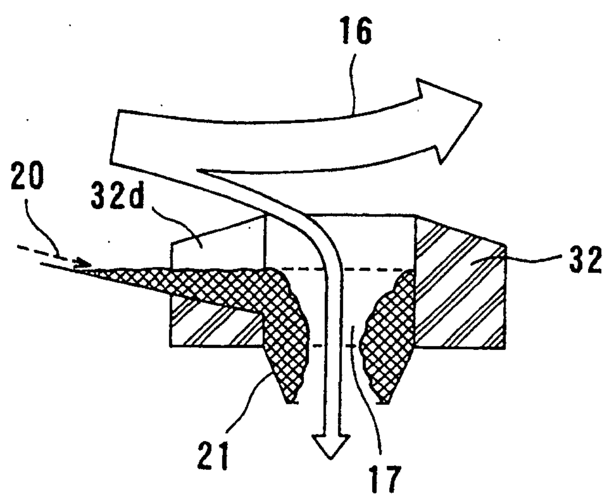
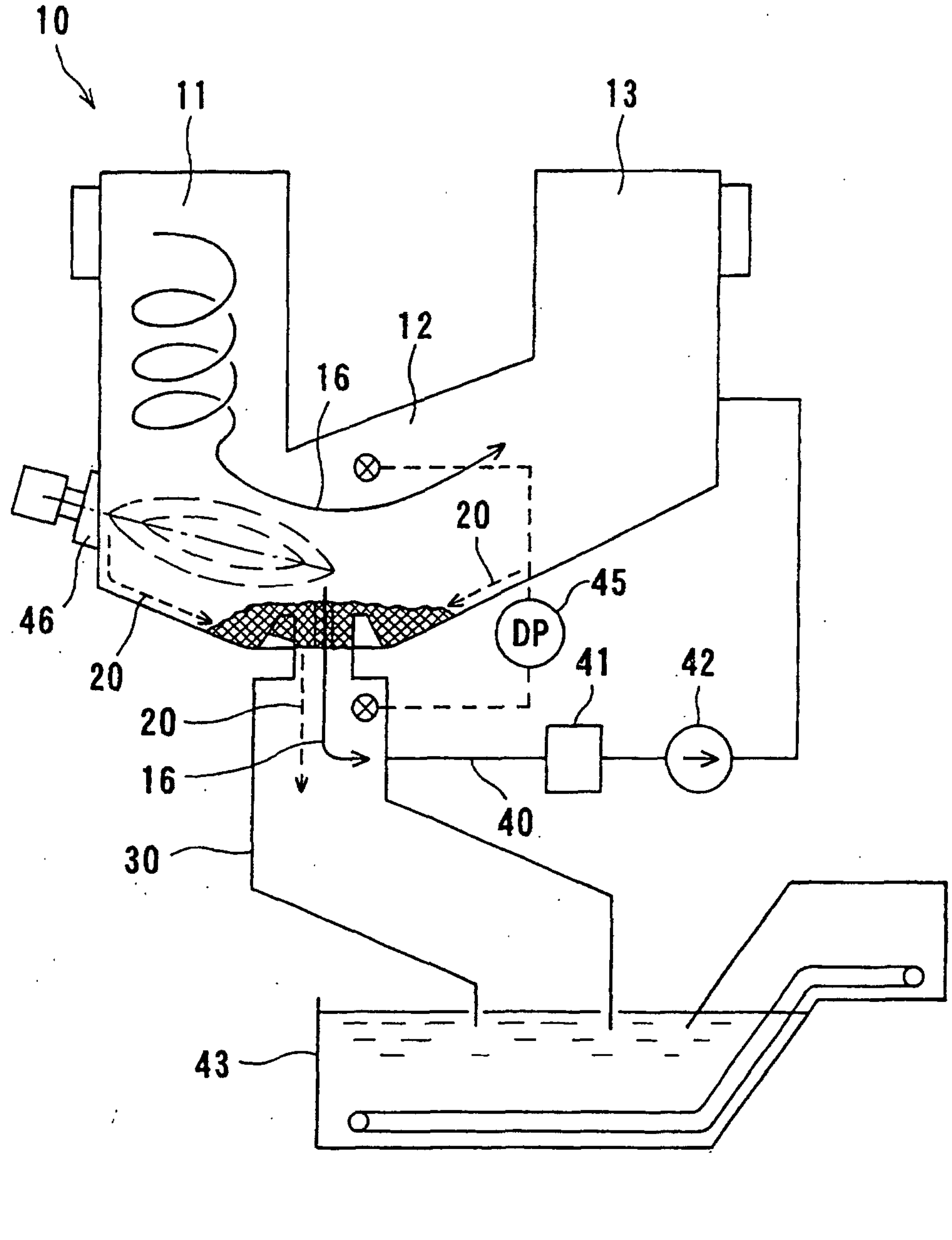


FIG. 18



INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP03/04568

A. CLASSIFICATION OF SUBJECT MATTER
Int.Cl⁷ F23G5/00, F23G5/027

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.Cl⁷ F23G5/00, F23G5/027, F23G5/16

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.
Y	JP 2000-283425 A (NKK Corp.), 13 October, 2000 (13.10.00), Full text; Fig. 1 (Family: none)	1-6
Y	JP 9-217921 A (Mitsui Engineering & Shipbuilding Co., Ltd.), 19 August, 1997 (19.08.97), Full text; Figs. 3, 4 (Family: none)	1-6,8,9
X Y	JP 2002-89823 A (Hitachi Zosen Corp.), 27 March, 2002 (27.03.02), Full text; Figs. 1, 3 (Family: none)	7 3,8,11,12

☒ 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
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"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 08 July, 2003 (08.07.03)	Date of mailing of the international search report 22 July, 2003 (22.07.03)
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/JP03/04568

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 11-241817 A (Ebara Corp.), 07 September, 1999 (07.09.99), Full text; Figs. 1, 4 (Family: none)	9-12
Y	JP 2001-147009 A (Kobe Steel, Ltd.), 29 May, 2001 (29.05.01), Full text; Figs. 1, 2 (Family: none)	10
Y	JP 2-115611 A (Kawasaki Heavy Industries, Ltd.), 27 April, 1990 (27.04.90), Full text; Fig. 3 (Family: none)	11,12

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

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP03/04568

Box I Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
   because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
   because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.:
   because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

Claims 1-6 relate to the refractory material of the slag falling port of a fusion furnace.
Claims 7 and 8 relate to the structure of the slag falling port of the fusion furnace.
Claims 9-12 relate to a waste processing method.

1. ☒ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest ☐ The additional search fees were accompanied by the applicant's protest.
☒ No protest accompanied the payment of additional search fees.

Form PCT/ISA/210 (continuation of first sheet (1)) (July 1998)