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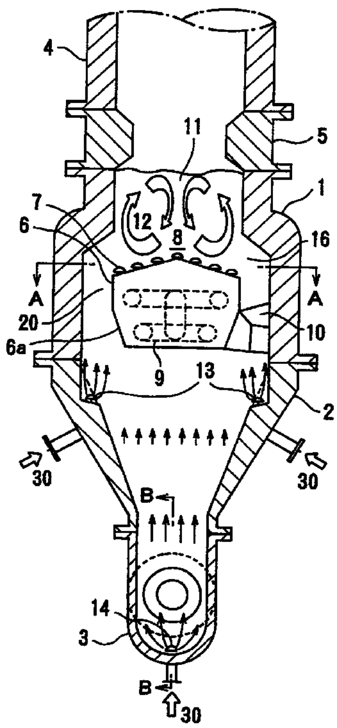
(54) FLUIDIZED BED GASIFICATION FURNACE

(57) The present invention relates to a fluidized-bed gasification furnace which can rapidly discharge incombustibles contained in a fuel, together with a fluidized medium. The fluidized-bed gasification furnace utilizes a fluidized-bed reactor and comprises a discharge port (16) provided in the vicinity of the floor in a fluidized bed for discharging a fluidized medium and connected to a fluidized medium discharge chutes (20a to 20d) extending downwardly, and a gas blow device (13) provided below the chutes.

F I G. 1 A



EP 1 058 051 A1

Description

Technical Field

[0001] The present invention relates to a fluidized-bed gasification furnace, and more particularly to a fluidized-bed gasification furnace characterized by discharge of a fluidized medium.

[0002] A fluidized bed is formed by supplying a gas upwardly into a particle-filled bed filled with particles of a fluidized medium, such as silica sand or iron oxide, having a size of about several tens of micrometers to about several millimeters for thereby fluidizing the fluidized medium. In a fluidized-bed reactor, the properties possessed by the fluidized bed such as the fluidity, uniformity, high heat capacity, and large surface area are utilized to rapidly, stably, and homogeneously conduct a chemical reaction. The fluidized-bed reactor has been applied to a catalytic cracking furnace in petroleum refining, and a combustion furnace and an incineration furnace for solid fuels such as coal, and extensively utilized in these fields.

Background Art

[0003] Fluidized-bed gasification furnaces possess excellent mixing properties and heat transfer efficiency because of the fluidized medium, and hence are advantageous in that size and properties of introducible fuels are less limited than entrained bed reactors. The fluidized-bed gasification furnaces, however, have a drawback that the operation temperature should be lower than that of the entrained bed reactors to prevent the fluidized medium and ash content in fuels from melting and adhering to each other at high temperatures, and hence inhibiting fluidization of the fluidized medium. Therefore, it is necessary that the operation temperature is about 900°C or lower when coal is used as the fuel, and about 600°C to about 800°C when wastes are used as the fuel, although influenced by the properties of wastes. When the wastes contain alkali metals, the operation temperature should be further lower.

[0004] The production of tar is a problem in the case of pyrolysis and gasification of wastes or coal at a relatively low temperature. In general, tar is in a vapor form at a temperature of around 600°C, and when the temperature is lowered to 200°C or below, tar is liquefied to develop adhesiveness, thus causing various troubles associated with handling of particles.

[0005] Further, the fluidized-bed gasification furnace has a feature that since a large amount of char stays within the furnace, when incombustibles and the like are withdrawn from the bed, high-temperature char is brought into contact with air and then combusted to increase the temperature thereof, thus tending to form clinker.

[0006] As described above, the fluidized bed gasification reactor has a feature in less restriction on the size and properties of introducible fuels. However, in the case of a fuel containing incombustibles such as coal or wastes, if such fuel having a large size is introduced as it is, then the incombustibles remaining within the reactor become large, and thus such incombustibles are required to be discharged from the reactor by some methods. However, withdrawing the fluidized medium at a high temperature of 500°C to 600°C from the fluidized bed is very difficult due to its high temperature even in the atmospheric-pressure reactor, and hence is hardly possible in the gasification furnace operated under pressure. Even if the fluidized medium can be successfully withdrawn from the fluidized bed, the withdrawal of the high-temperature fluidized medium causes large heat loss which reduces the efficiency of heat utilization. Further, in withdrawing the fluidized medium, a large amount of char included in the fluidized medium may be combusted upon contact with air, leading to unexpected troubles.

[0007] Cooling the fluidized medium for avoiding the above problem causes liquefaction of tar vapor, often leading to various troubles. Therefore, the fuel should be crushed to a small size and then introduced into the fluidized-bed gasification furnace to dispense with withdrawal of incombustibles. This fails to utilize the feature of the fluidized-bed reactor.

Disclosure of Invention

[0008] The present invention has been made in view of the above drawbacks. It is therefore an object of the present invention to provide a fluidized-bed gasification furnace having excellent practicability which can be safely operated not only under atmospheric pressure but also under high pressure, while utilizing such feature of the fluidized-bed reactor that less restriction on the size and properties of introducible fuels are imposed.

[0009] In order to achieve the above object, according to the present invention, there is provided a fluidized-bed gasification furnace utilizing a fluidized-bed reactor, comprising: a discharge port provided in the vicinity of a floor in a fluidized bed for discharging a fluidized medium, the discharge port being connected to a fluidized medium discharge chute extending downwardly; and a gas blow device provided below the chute.

[0010] In the fluidized-bed gasification furnace, a device for mechanically withdrawing the fluidized medium is provided in the vicinity of the lowermost part of the fluidized medium discharge chute. This device preferably comprises a screw conveyor.

[0011] A gas blow device is preferably provided also at the lowermost part of the fluidized medium discharge chute. In these gas blow devices, steam, CO_2, or oxygen-free gas may be used as a gas to be blown.

[0012] Further, the fluidized-bed reactor used in the present invention is preferably divided into units performing respective functions so that the fluidized-bed reactor can easily deal with fuels having different properties by changing the combination of each of units.

Brief Description of Drawings

[0013]

FIGS. 1A, 1B, and 1C are cross-sectional views showing the structure of a cylindrical fluidized-bed gasification furnace according to an embodiment of the present invention, and FIG. 1A is a vertical cross-sectional view showing the fluidized-bed gasification furnace, FIG. 1B is a cross-sectional view taken along a line A-A of FIG. 1A, and FIG. 1C is a cross-sectional view taken along a line B-B of FIG. 1A;

FIGS. 2A, 2B, and 2C are cross-sectional views showing the structure of a rectangular fluidized-bed gasification furnace according to another embodiment of the present invention, and FIG. 2A is a vertical cross-sectional view showing the fluidized-bed gasification furnace, FIG. 2B is a cross-sectional view taken along a line A-A of FIG. 2A, and FIG. 2C is a cross-sectional view taken along a line B-B of FIG. 2A;

FIG. 3 is a schematic view showing the whole construction of components around a gasification furnace according to an embodiment of the present invention;

FIG. 4 is a schematic view showing the whole construction of components around a gasification furnace according to another embodiment of the present invention;

FIG. 5 is a schematic view showing the whole construction of components around a gasification furnace according to a further embodiment of the present invention;

FIG. 6 is a vertical cross-sectional view showing a modified fluidized-bed gasification furnace according to the present invention; and

FIG. 7 is a vertical cross-sectional view showing another modified fluidized-bed gasification furnace according to the present invention.

Best Mode for Carrying Out the Invention

[0014] The present invention will be described below with reference to the accompanying drawings.

[0015] FIGS. 1A, 1B, and 1C are cross-sectional views showing the structure of a cylindrical fluidized-bed gasification furnace according to an embodiment of the present invention. FIG. 1A is a vertical cross-sectional view showing the fluidized-bed gasification furnace, FIG. 1B is a cross-sectional view taken along a line A-A of FIG. 1A, and FIG. 1C is a cross-sectional view taken along a line B-B of FIG. 1A.

[0016] The fluidized-bed gasification furnace using a cylindrical fluidized-bed reactor shown in FIGS. 1A through 1C comprises a fluidized-bed unit 1, an under-furnace hopper unit 2, a medium discharge device unit 3, a free board unit 4, and a deflector unit 5. According to the present invention, the fluidized-bed reactor comprises the fluidized-bed unit 1, the under-furnace hopper unit 2, and the medium discharge device unit 3. Adjacent units are connected to each other by flanges. A fluidizing gas dispersion device 6 having a conical top surface is provided inside the fluidized-bed unit 1, and has a plurality of fluidizing gas dispersion nozzles 7 on the top surface thereof.

[0017] The interiors of the fluidized-bed unit 1 and the units below the fluidized-bed unit 1 are filled with a fluidized medium 11. The fluidized medium above the fluidizing gas dispersion device 6 is fluidized by a fluidizing gas blown from the fluidizing gas dispersion nozzles 7 to form a fluidized bed 8. An fluidizing gas header 9 comprising at least two divided segments are housed in the fluidizing gas dispersion device 6, and the velocity of the fluidizing gas blown from the fluidizing gas dispersion nozzles 7 is regulated so that the velocity of the fluidizing gas blown into the peripheral portion is larger than the velocity of the fluidizing gas blown into the central portion, thereby developing internal revolving flows 12 of the fluidized medium in the fluidized bed. The temperature of the fluidized medium over the fluidizing gas dispersion device 6 is kept at 400°C to 1,000°C, preferably 500°C to 800°C.

[0018] A discharge port 16 extending radially outwardly for the fluidized medium is provided inside the fluidized-bed unit 1 and above the periphery of the fluidizing gas dispersion device 6. Below the discharge port 16, there is provided a gap 20 defined between the fluidizing gas dispersion device 6 and the inner wall of the fluidized-bed unit 1. This gap 20 serves as a discharge chute for the fluidized medium, and is divided into four chutes 20a to 20d by supports 10 for fixing the fluidizing gas dispersion device 6 to the inner wall of the fluidized-bed unit 1. Pipes for supplying fluidizing gases from the exterior of the fluidized-bed unit 1 into the fluidizing gas header 9 may be provided inside the supports 10.

[0019] The chutes 20a to 20d are preferably provided so as to face the whole side surface of the fluidizing gas dispersion device 6 in order to prevent incombustibles from accumulating in the fluidized bed 8. In this case, the support 10 necessarily has an angled upper portion, the top of which is acute. When pipes are incorporated inside the support 10, the support 10 should have a certain width. Therefore, the support 10 should have a shape broadened downwardly, with the result that the width of the chutes 20a to 20d is reduced in the circumferential direction. In the chutes 20a to 20d, however, in order to avoid clogging with incombustibles or the like therein, it is necessary to avoid decreasing the horizontal sectional area of the chutes 20a to 20d gradually downwardly. Therefore, in the gasification furnace according to this embodiment, the lower side 6a of the fluidizing gas dispersion device 6 is downwardly inclined toward the centerline. As a result, the dimension in the radial direction of the chutes 20a to 20d is downwardly increased to prevent the horizontal sectional area thereof from decreasing downwardly.

[0020] Each of gas blow nozzles 13 is provided below each of the chutes 20a to 20d and in the vertical direction of each of the chutes 20a to 20d. The interiors of the chutes can be purged with steam or inert gas introduced from the gas blow nozzles 13 in order to prevent tar and oxygen from diffusing therethrough, or to eliminate the clogging of the chutes by vigorously fluidizing the fluidized medium.

[0021] The medium discharge device unit 3 is connected to the lower end of the under-furnace hopper unit 2. The inner side of the under-furnace hopper unit 2 in the gasification furnace according to this embodiment is inclined so as to correspond to the size of the inlet of the medium discharge device unit 3, and hence is throttled as a whole. When incombustibles having a possibility of forming a bridge due to the throttle, for example, incombustibles such as wires, are required to be discharged, a straight vertical wall may, of course, be adopted, or alternatively the inner side may be eccentric so as to have both vertical section and inclined section.

[0022] A medium discharge device 15 is provided at the lower part of the medium discharge device unit 3. In the gasification furnace according to this embodiment, a screw conveyor is used as the medium discharge device 15. A discharge device which can discharge incombustibles in the transverse direction, such as a chain conveyor, may be used depending on the properties of incombustibles. In the gasification furnace according to this embodiment, the medium discharge device 15 is transversely provided in the horizontal direction. Alternatively, the medium discharge device 15 may be vertically inclined.

[0023] Further, a gas blow nozzle 14 is provided at the lowermost part of the medium discharge device unit 3 and below the medium discharge device 15. In the case of the gasification furnace according to this embodiment, although only one gas blow nozzle 14 is provided, since the purpose of this nozzle is to distribute a gas over the whole area of the passage in a connection between the medium discharge device unit 3 and the under-furnace hopper unit 2, the number of nozzles may be increased as necessary. The concentration of incombustibles can be expected by classification effect caused by a gas blown through the gas blow nozzle 14, thus reducing the amount of the discharged fluidized medium, and simultaneously carry-over heat loss.

[0024] Steam, CO_2, or oxygen-free gas 30 is blown from the gas blow nozzle 14. If steam and CO_2 are blown from the gas blow nozzle 14, and carbon particles are contained in the fluidized medium within the chutes, then the cooling effect can further be enhanced by the following endothermic reaction.

$$C + H_2O \rightarrow CO + H_2$$

$$C + CO_2 \rightarrow 2CO$$

[0025] The same effect can, of course, be obtained by blowing steam or CO_2 from the gas blow nozzles 13.

[0026] When steam is blown from the nozzles 13 and the nozzle 14, it is necessary that the temperature of blown steam is higher than the saturation temperature at the operation pressure of the gasification furnace. In the medium discharge device and the like, heat insulation, steam heat tracing, or other measures should be taken, if necessary, so that the internal temperature is not lowered to the dew point or below, and dew condensation should be prevented.

[0027] The gasification furnace shown in FIGS. 1A through 1C is divided into units performing respective functions. The whole gasification furnace may, of course, be formed as an integral structure. In particular, in the case of a large furnace, since each section is large and a sufficient space for maintenance can be ensured, it is not necessary to perform inspection in such a state that the units are separated from each other. Therefore, the whole gasification furnace may be formed as an integral structure. However, when the gasification furnace is used under pressure, the volume of the gasification furnace is small, and hence it is difficult to perform internal inspection and the like. Accordingly, in this case, the separable unit-type gasification furnace as shown in FIGS. 1A through 1C may be effective.

[0028] The separable unit-type structure has another advantage in that the structure can be easily changed depending on the properties of fuels. For example, in the case of a fuel that is difficult to gasify and thus requires a long retention time within the fluidized bed, as shown in FIG. 6, a straight pipe section 1a may be additionally provided between the deflector unit 5 and the fluidized-bed unit 1 to increase the bed height. On the other hand, in the case of a fuel that requires a long retention time within the free board due to low specific gravity and low retention ratio within the fluidized bed, as shown in FIG. 7, a free board unit 4 bulged outwardly in its portion slightly above the flange may be used to increase the internal volume of the free board. Thus, the gasification furnace can easily deal with various fuels by modifying only a necessary portion as shown in FIGS. 6 and 7 without the modification of the whole gasification furnace.

[0029] FIGS. 2A, 2B, and 2C are cross-sectional views showing the structure of a rectangular fluidized-bed gasification furnace according to another embodiment of the present invention. FIG. 2A is a vertical cross-sectional view showing the fluidized-bed gasification furnace, FIG. 2B is a cross-sectional view taken along a line A-A of FIG. 2A, and FIG. 2C is a cross-sectional view taken along a line B-B of FIG. 2A.

[0030] Like components shown in FIGS. 2A through 2C which are designated by the same reference numerals as those shown in FIGS. 1A through 1C have the same function, structure, and operation as those shown in FIGS. 1A through 1C.

[0031] In the fluidized-bed gasification furnace shown in FIGS. 2A through 2C, the outer wall of the fluidized-bed unit 1 is in the form of rectangle. A rectangular fluidizing gas dispersion device 6 provided in the fluidized-bed unit 1 has an angled upper portion. In this embodiment, two internal revolving flows 12, which are symmetrical with respect to a central plane, are formed respectively between the central portion and the left peripheral portion and between the central portion and the right peripheral portion. An outwardly extending fluidized medium discharge port 16 is provided in the fluidized-bed unit 1 and above the periphery of the fluidizing gas dispersion device 6. Below the discharge port 16, there is provided a gap 20 defined between the fluidizing gas dispersion device 6 and the inner wall of the fluidized-bed unit 1. This gap 20 serves as a fluidized medium discharge chute. As shown in FIG. 2B, the gap 20 comprises two chutes 20a and 20b. Three gas blow nozzles 13 are provided below each of the chutes 20a, 20b and in the vertical direction of the chutes 20a, 20b.

[0032] Other construction of this embodiment is the same as that of the embodiment shown in FIGS. 1A through 1C. The function and effect of this embodiment are the same as those of the embodiment shown in FIGS. 1A through 1C.

[0033] FIG. 3 is a schematic view showing the whole construction of components around the gasification furnace used under pressure according to an embodiment of the present invention. According to this embodiment, a lock hopper 102 for pressure seal is connected to the downstream side of the medium discharge device unit provided at the lower part of the gasification furnace 101 having a structure shown in FIGS. 1A through 1C or FIGS. 2A through 2C. A vibrating screen 103 is provided downstream of the lock hopper 102. Incombustibles 61 are separated from a fluidized medium 60 by the vibrating screen 103. The incombustibles 61 are discharged to the outside of the system, while the fluidized medium 60 is returned into the furnace. The fluidized medium 60 separated from the incombustibles 61 by the vibrating screen 103 is carried by a fluidized medium conveyor 104, passed through the lock hopper 105 for a fluidized medium, and returned to the gasification furnace 101 by a fluidized medium feed conveyor 106. In this construction, since the portion up to the lock hopper 102 is pressurized, dew condensation tends to occur. Therefore, measures such as heat insulation or steam heat tracing are preferably taken for preventing dew condensation.

[0034] FIG. 4 is a schematic view showing the whole construction of components around the gasification furnace used under pressure according to another embodiment of the present invention. The fluidized medium carried by the fluidized medium conveyor 104 in the same manner as in FIG. 3 is once received in a fluidized medium hopper 107. The flow rate of the fluidized medium can be adjusted by a constant-rate medium supply device 108. Further, a changeover chute 109 permits the fluidized medium to be fed through the lock hopper 105 into the furnace, or alternatively permits the fluidized medium together with a fuel 50 to be fed through a lock hopper 110 into the furnace by a feed conveyor 111.

[0035] FIG. 5 is a schematic view showing the whole construction of components around the gasification furnace used under atmospheric pressure according to another embodiment of the present invention. A mixture of incombustibles and a fluidized medium discharged from the gasification furnace 101 is carried by a conveyor 104 and is separated into incombustibles 61 and a fluidized medium 60 by a vibrating screen 103. Thereafter, the fluidized medium 60 is fed into the gasification furnace 101 by a fluidized medium feed conveyor 106. When the fuel contains a large amount of incombustibles having a small particle size that form a fluidized medium, the passage is switched by the changeover chute 109 to store an excessive fluidized medium in a fluidized medium hopper 107, and, as needed, the fluidized medium is supplied to the fluidized medium feed conveyor 106 by a constant-rate supply device 108, and then introduced into the furnace.

[0036] In the case of a system having no seal mechanism in the section for withdrawing the fluidized medium, as shown in FIG. 5, special attention should be paid to the possibility that steam introduced from the lowermost part of the gasification furnace 101 does not flow into the fluidized bed section but into the conveyor 104. Such a flow causes steam to condense in the conveyor and to thus moisten the fluidized medium. This is often causative of deteriorated handling and adhesion of fines of limestone or gypsum contained in the fluidized medium. In addition, since the steam does not flow toward the fluidized bed section, purging function to be expected by steam is not exerted, and hence troubles associated with tar or char in the chute for withdrawing the fluidized medium occur.

[0037] Accordingly, it is necessary to allow steam introduced from the lowermost part of the gasification furnace 101 to surely flow toward the fluidized bed. One method is to use a conveyor 104 of such a type that the interior of the conveyor is filled with the fluidized medium. This type of conveyor has a problem that required power is large because the fluidized medium present in the interior of the conveyor should be always agitated. Another method is to provide a seal damper between the outlet of the fluidized medium discharge conveyor provided at the bottom of the gasification furnace 101 and the conveyor 104. In this method, since the function of maintaining the sealed state while discharging the fluidized medium is necessary, a double damper system is preferably adopted. However, a single damper cooperated with the operation and stop of the fluidized medium discharge conveyor can be expected to provide a certain degree of such effect.

[0038] The present invention has the following effects.

(1) Incombustibles are withdrawn in a radially outward direction or in an outward direction as viewed from the fluidized bed furnace. Therefore, the incombustibles neither get entangled nor form a bridge, and thus can be easily discharged.
(2) Blowing steam, CO_2, or oxygen-free gas through nozzles provided at the lower part of each of the chutes to vigorously fluidize the fluidized medium permits incombustibles to be actively moved. This can eliminate a clogging trouble in the chute section.
(3) Blowing steam or inert gas composed of CO_2 or oxygen-free gas through nozzles provided at the bottom of the chutes and at the lowermost part of the medium discharge device unit permits the sensible heat of the incombustibles and the fluidized medium to be recovered by direct heat exchange with steam and to be returned into the furnace.
(4) Simultaneously, the chute purge function of steam or inert gas can prevent the vaporized tar from entering into the chute section, and hence can prevent various troubles caused by tar after cooling of the fluidized medium.
(5) Even if the properties of the fuel are such that char tends to accumulate and a large amount of char is left within the bed, the effect of steam or inert gas can prevent oxygen from entering into the chute section. Therefore, clinker troubles caused by the combustion of char in the chutes can be prevented.
(6) Simultaneously, a produced gas is prevented from entering into a portion downstream of the chutes. Therefore, even if a fuel that produces a gas which becomes strongly corrosive upon dew condensation, such as hydrogen chloride, is gasified, there is no fear of corrosion.
(7) Further, since the incombustibles and the fluidized medium to be discharged to the outside of the furnace can be cooled by steam or inert gas, it is not necessary to use high-grade materials having heat-resistance and corrosion-resistance in the medium discharge device, and thus device cost can be lowered.
(8) Even when the gasification furnace is used under pressure, the temperature of a pressure seal section downstream of the medium discharge device can be lowered. Therefore, pressure sealing can be achieved by simple equipment such as a lock hopper.
(9) If agglomerates having a large particle size should be produced by clinker troubles or the like, the agglomerates having a large particle size are broken into a suitable size by the forced-discharge function of the medium discharge device. This can prevent clogging troubles in the fluidized medium discharge system.

Industrial Applicability

[0039] The present invention is preferably applicable to an apparatus for producing a gas from fuels such as wastes or coal with a fluidized bed.

Claims

1. A fluidized-bed gasification furnace utilizing a fluidized-bed reactor, comprising:

   a discharge port provided in the vicinity of a floor in a fluidized bed for discharging a fluidized medium, the discharge port being connected to a fluidized medium discharge chute extending downwardly; and a gas blow device provided below said chute.

2. A fluidized-bed gasification furnace according to claim 1, wherein a device for mechanically withdrawing the fluidized medium is provided in the vicinity of the lowermost part of said fluidized medium discharge chute.

3. A fluidized-bed gasification furnace according to claim 1 or 2, wherein said gas blow device is provided at the lowermost part of said fluidized medium discharge chute.

4. The fluidized-bed gasification furnace according to claim 1, 2, or 3, wherein said gas blow device uses steam, carbon dioxide, or oxygen-free gas as a gas to be blown.

5. The fluidized-bed gasification furnace according to claim 2, 3, or 4, wherein said device for withdrawing the fluidized medium comprises a screw conveyor.

6. The fluidized-bed gasification furnace according to any one of claims 1 through 5, wherein said fluidized-bed reactor is divided into units performing respective functions so that said fluidized-bed reactor can easily deal with fuels having different properties by changing the combination of each of units.

FIG. 1A

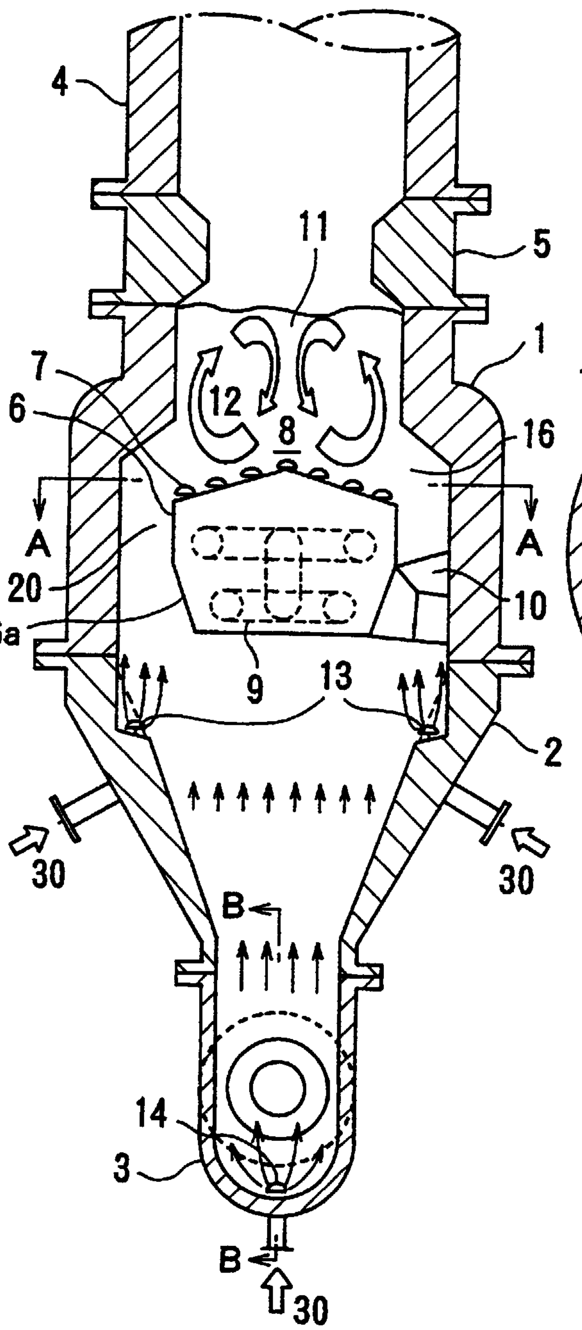


FIG. 1B

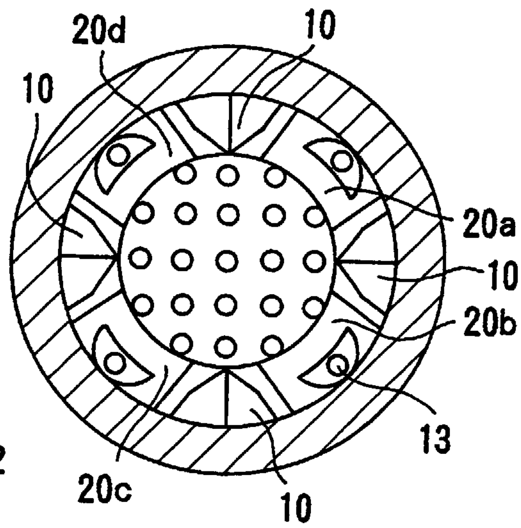
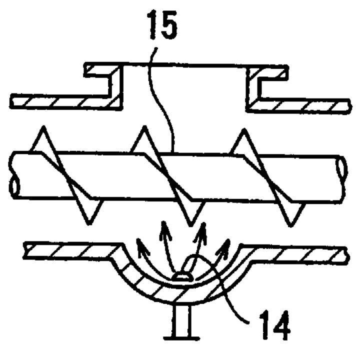
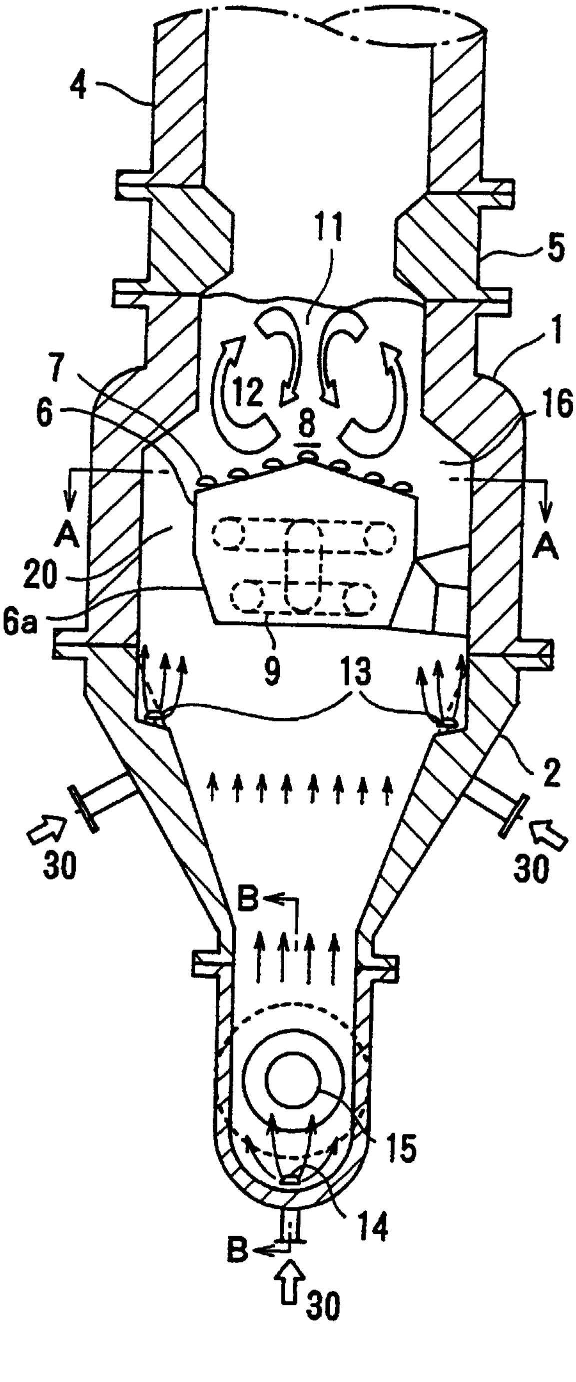


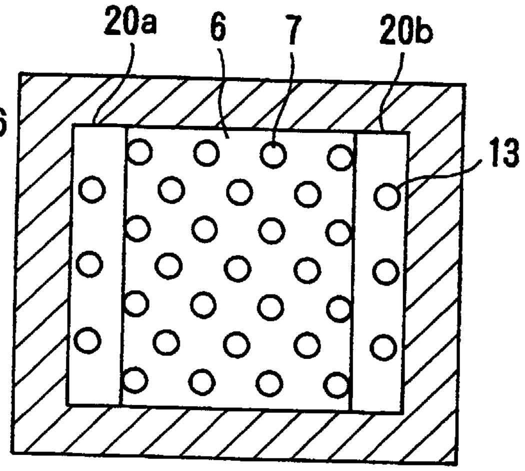
FIG. 1C



F I G. 2A



F I G. 2 B



F I G. 2 C

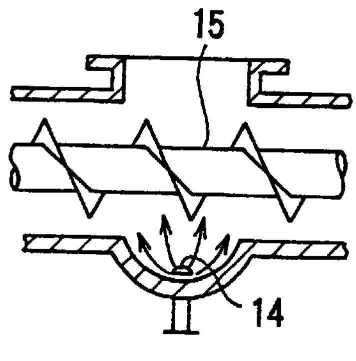


FIG. 3

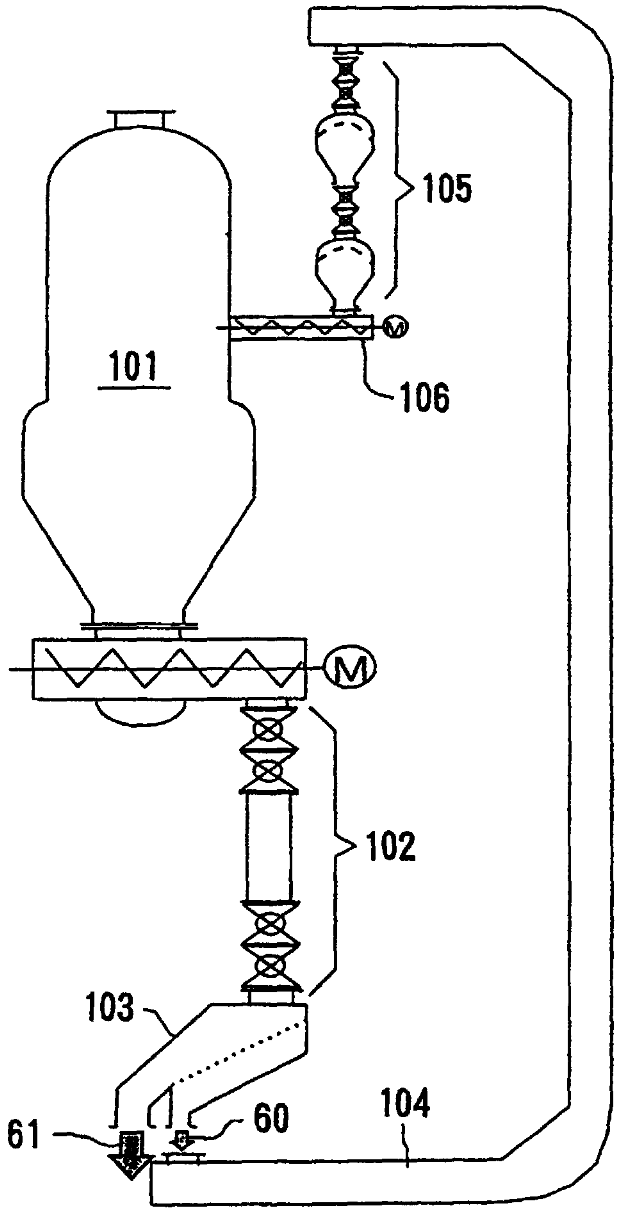


FIG. 4

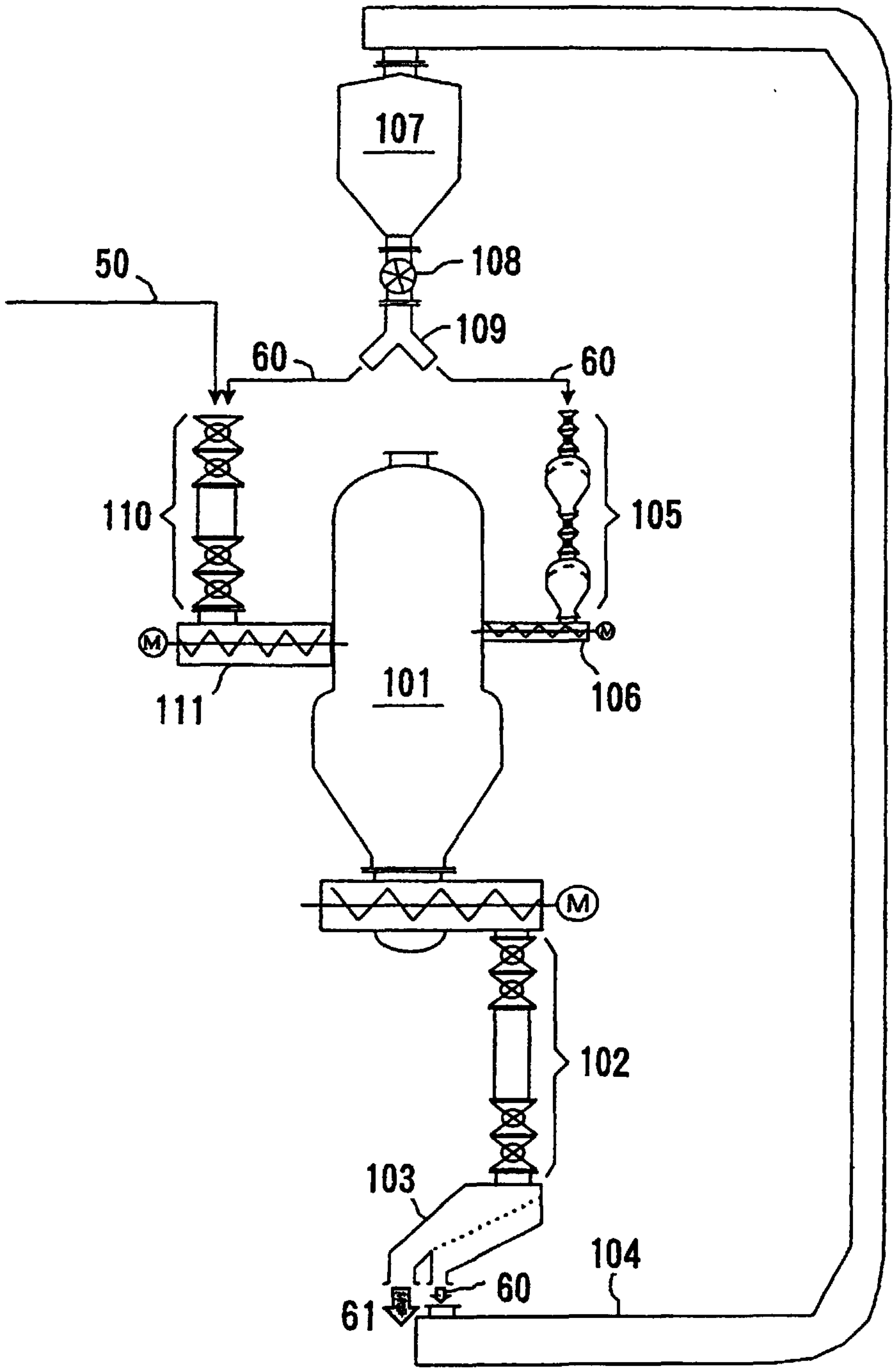


FIG. 5

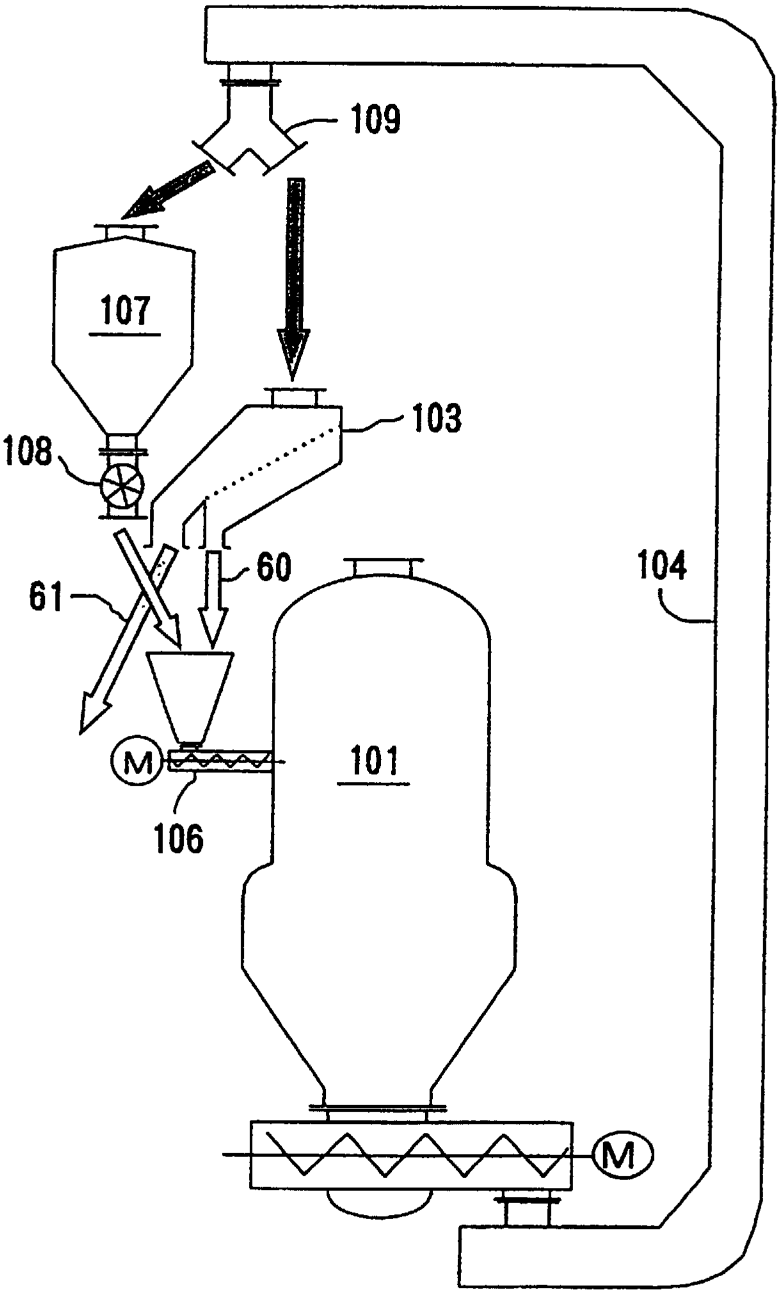
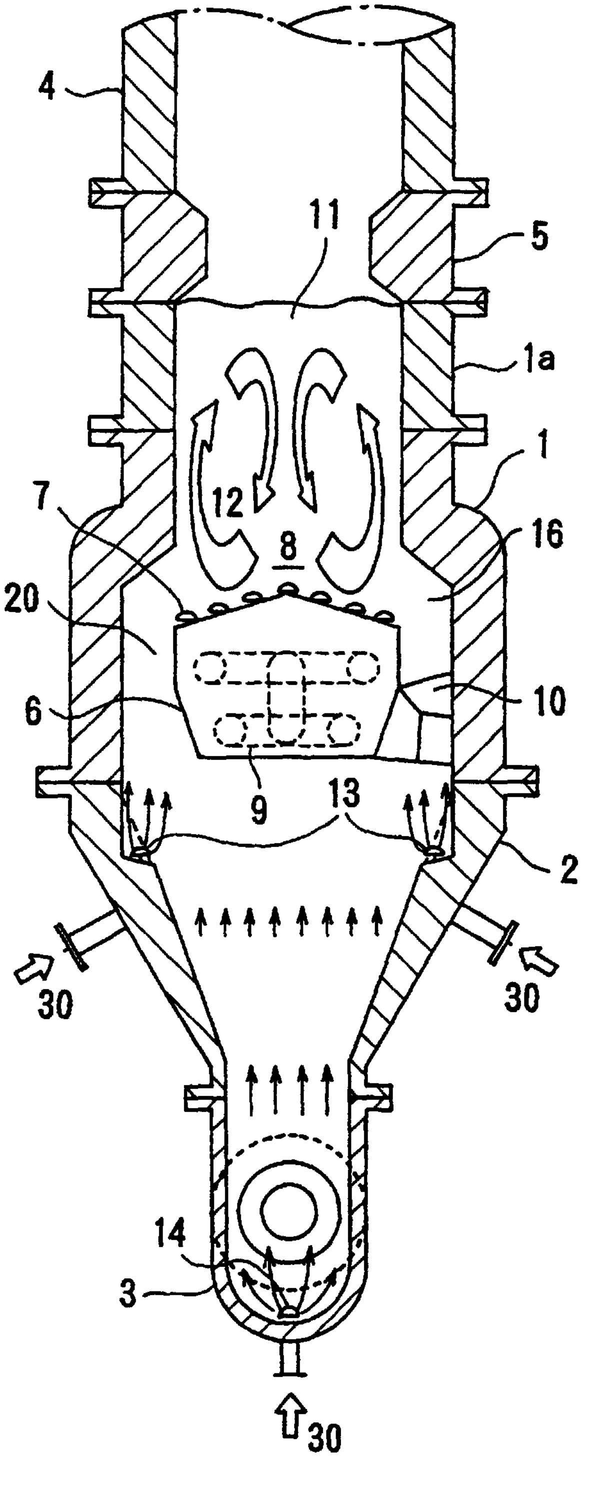
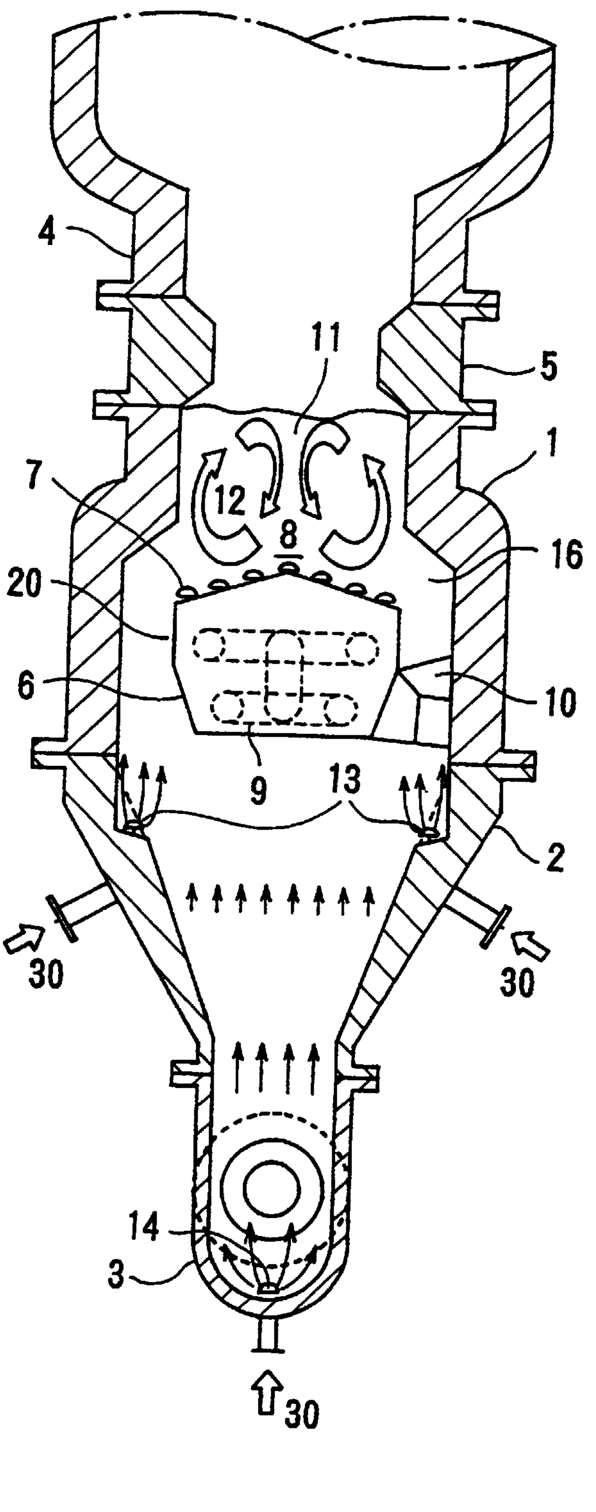


FIG. 6



F I G. 7



INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP99/00946

A. CLASSIFICATION OF SUBJECT MATTER
Int.Cl[6] F23C11/02, F23G5/30, 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.Cl[6] F23C11/02, F23G5/30, F23G5/027

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

Jitsuyo Shinan Koho	1940-1996	Toroku Jitsuyo Shinan Koho	1994-1999
Kokai Jitsuyo Shinan Koho	1971-1999	Jitsuyo Shinan Toroku Koho	1996-1999

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.
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X	Full text ; Figs. 2, 3	1-2
Y	Full text ; Figs. 2, 3	5
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☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

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