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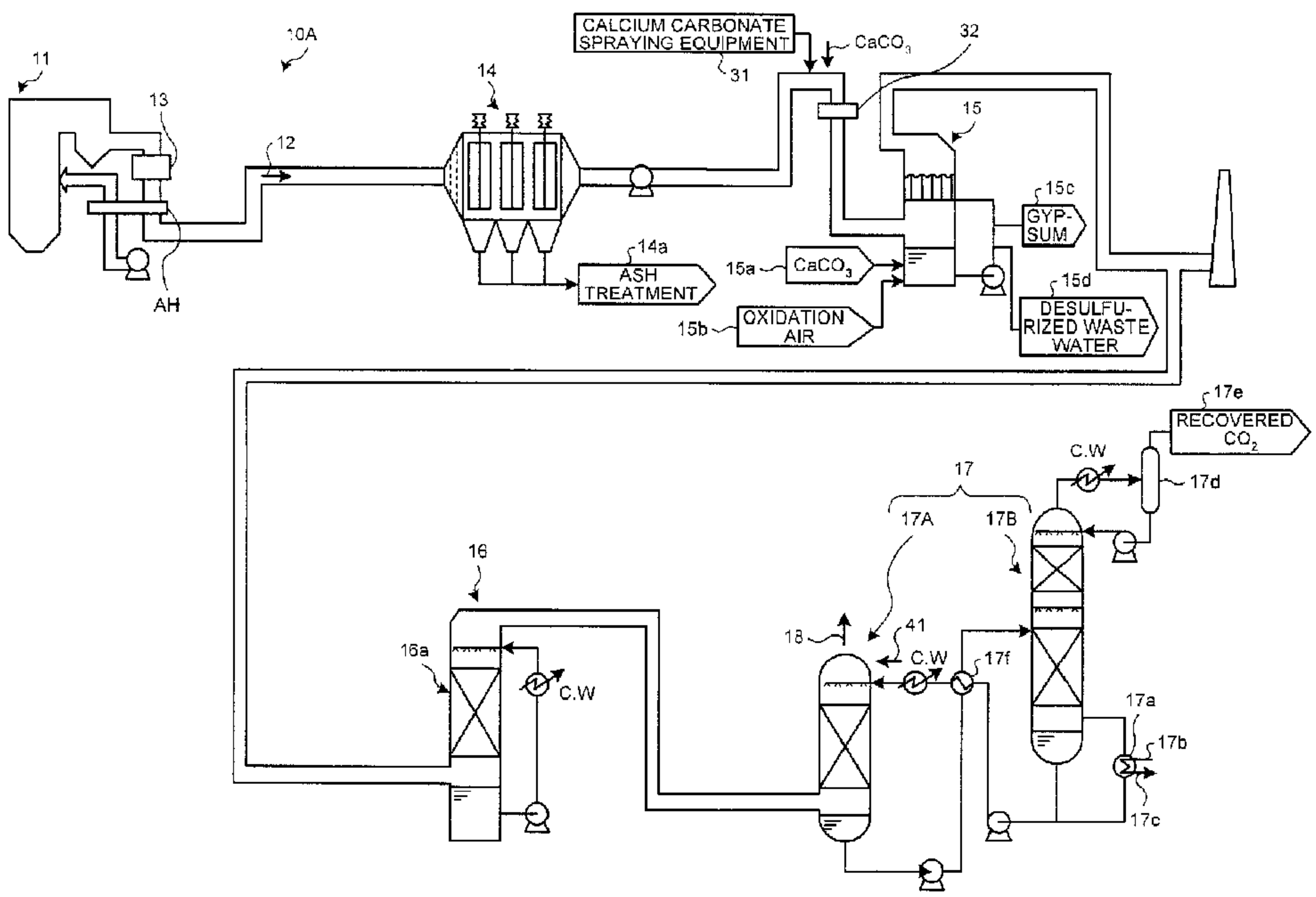

(57) Abrégé/Abstract:
So_x removal equipment (15) for reducing sulfur oxides from flue gas (12) from a boiler (11), a cooler (16) which is provided on a downstream side of the SO_x removal equipment (15), for reducing the sulfur oxides that remain in the flue gas and for decreasing a gas temperature, CO_2 recovery equipment (17) including an absorber (17A) for bringing CO_2 in the flue gas into contact with a CO_2 absorption liquid so as to be reduced, and a regenerator (17B) for causing the CO_2 absorption liquid to emit CO_2 so as to recover CO_2 and regenerate the CO_2 absorption liquid, a heat exchanger (32) which is provided on an inlet passage side of the SO_x removal equipment (15), for decreasing a temperature of the flue gas, and calcium carbonate spraying equipment (31) for spraying calcium carbonate between the heat exchanger (32) and an electric dust collector (14) are included, and a mist generation material in the flue gas is converted from a gas state to a mist state to arrest and reduce the mist generation material in the mist state using calcium carbonate.

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ABSTRACT

SO_x removal equipment (15) for reducing sulfur oxides from flue gas (12) from a boiler (11), a cooler (16) which is provided on a downstream side of the SO_x removal equipment (15), for reducing the sulfur oxides that remain in the flue gas and for decreasing a gas temperature, CO_2 recovery equipment (17) including an absorber (17A) for bringing CO_2 in the flue gas into contact with a CO_2 absorption liquid so as to be reduced, and a regenerator (17B) for causing the CO_2 absorption liquid to emit CO_2 so as to recover CO_2 and regenerate the CO_2 absorption liquid, a heat exchanger (32) which is provided on an inlet passage side of the SO_x removal equipment (15), for decreasing a temperature of the flue gas, and calcium carbonate spraying equipment (31) for spraying calcium carbonate between the heat exchanger (32) and an electric dust collector (14) are included, and a mist generation material in the flue gas is converted from a gas state to a mist state to arrest and reduce the mist generation material in the mist state using calcium carbonate.

DESCRIPTION

AIR POLLUTION CONTROL SYSTEM AND METHOD

Field

[0001] The present invention relates to an air pollution control system and method that reduce CO_2 from flue gas.

Background

[0002] In recent years, the greenhouse effect due to CO_2 is indicated as one of causes of the global warming phenomenon, and the countermeasures thereof become an internationally urgent matter to protect the global environment. CO_2 generation sources reach all human activity fields in which fossil fuels are burned, and there is a tendency to further strengthen the demand for suppression of the discharge thereof. For this, for a power generation facility such as a thermal power plant that uses a large amount of fossil fuels, a method of bringing combustion flue gas of an industrial facility such as a boiler or a gas turbine into contact with an amine-based CO_2 absorption liquid to reduce and recover CO_2 from the combustion flue gas and an air pollution control system which stores the recovered CO_2 without emission to air has been energetically researched.

[0003] CO_2 recovery equipment which has, as the process of reducing and recovering CO_2 from the combustion flue gas using a CO_2 absorption liquid as described above, a process of bringing the combustion flue gas into contact with the CO_2 absorption liquid in a CO_2 absorber (hereinafter, also simply referred to as "absorber"), and a process of heating the CO_2 absorption liquid that absorbs CO_2 in an absorption liquid regenerator (hereinafter, also simply referred to as "regenerator") to emit CO_2 and regenerate the CO_2 absorption liquid so as to be circulated through the CO_2 absorber to be reused, is proposed (for example, Patent

Literature 1).

[0004] In the CO_2 absorber, through countercurrent contact using an amine-based CO_2 absorption liquid such as alkanolamine, CO_2 in the flue gas is absorbed by the CO_2 absorption liquid in a chemical reaction (exothermic reaction), and the flue gas from which CO_2 is reduced is emitted to the outside of the system. The CO_2 absorption liquid that absorbs CO_2 is also called a "rich solution". The rich solution is pressurized by a pump, is heated in a heat exchanger by a high-temperature CO_2 absorption liquid (lean solution) regenerated as CO_2 is emitted in the regenerator, and is supplied to the regenerator.

Citation List

Patent Literature

[0005] Patent Literature 1: Japanese Laid-open Patent Publication No. 3-193116

Summary

[0006] However, in the air pollution control system, in a case where a mist generation material that is a generation source of mist generated in the absorber of the CO_2 recovery equipment is included in the flue gas introduced to the CO_2 absorber that absorbs CO_2 in the CO_2 recovery equipment, there is a problem in that the CO_2 absorption liquid is entrained by the mist generation material and thus the amount of CO_2 absorption liquid that scatters to the outside of the system is increased.

Such a case, where the scattering of the CO_2

absorption liquid to the outside of the system occurs, is connected to a significant loss of the CO_2 absorption liquid, and an unnecessary amount of the CO_2 absorption liquid has to be replenished. Therefore, the scattering of the CO_2 absorption liquid to the outside of the system needs to be suppressed.

[0007] Here, the establishment of an air pollution control system which suppresses the scattering of a CO_2 absorption liquid from a CO_2 absorber is desired.

[0008] In order to solve the problem, some embodiments of the present disclosure may provide an air pollution control system and method capable of significantly reducing entraining of a CO_2 absorption liquid when flue gas from which CO_2 is reduced is discharged to the outside of a system, and performing an appropriate air pollution control.

[0009] According to a first aspect of the present invention, there is provided an air pollution control system including a CO_2 recovery equipment having an absorber for bringing CO_2 in flue gas from a boiler into contact with a CO_2 absorption liquid so as to absorb the CO_2 from the flue gas and a regenerator for causing the CO_2 absorption liquid to emit CO_2 so as to recover the CO_2 and regenerate the CO_2 absorption liquid, the air pollution control system comprising: dust reduction equipment for reducing particulates in flue gas; calcium carbonate spraying equipment provided downstream of the dust reduction equipment and for spraying calcium carbonate into the flue gas; a heat exchanger provided downstream of the calcium carbonate spraying equipment and for cooling the flue gas so as to convert mist generation material containing SO_3

from a gaseous state to a mist state so that mist generation material in the mist state contacts calcium carbonate sprayed into the flue gas and is nurtralized, thereby reducing the amount of mist generation material in the flue gas; SO_x removal equipment provided downstream of the heat exchanger and for reducing sulfur oxides in the flue gas; and a cooler provided downstream of the SO_x removal equipment and upstream of the CO_2 recovery equipment, for reducing sulfur oxides that remain in the flue gas and for decreasing gas temperature; whereby scattering of the CO_2 absorption liquid as part of a mist generated by the mist generation material is alleviated by decreasing an amount of SO_3 mist to 3 ppm or less, wherin the CO_2 absorption liquid is an amine-based CO_2 absorption liquid.

[0010] In some embodiments, according to a second aspect, there is provided the air pollution control system according to the first aspect, further including NO_x removal equipment which reduces nitrogen oxides from the flue gas.

[0011] According to a third aspect of the present invention, there is provided an air pollution control system including: SO_x removal equipment for reducing sulfur oxides from flue gas from a boiler; a cooler which is provided on a downstream side of the SO_x removal equipment for reducing the sulfur oxides that remain in the flue gas and for decreasing a gas temperature; CO_2 recovery equipment including an absorber for bringing CO_2 in the flue gas into contact with a CO_2 absorption liquid so as to be reduced; and a regenerator for causing the CO_2 absorption liquid to emit CO_2 so as to recover CO_2 and regenerate the CO_2 absorption liquid; and a heat exchanger which is provided on an upstream side of the SO_x removal equipment, for decreasing a temperature of the flue gas to an acid dew point or less, wherein, in the heat exchanger, a mist generation material in the flue gas is converted from a gas state to a condensed state so as to reduce the mist generation material.

[0012] In some embodiments, according to a fourth aspect, there is provided the air pollution control system according to the third aspect, further including alkaline neutralizer spraying equipment which sprays an alkaline neutralizer between the heat exchanger and the SO_x removal equipment, wherein the mist generation material in the flue gas is converted from the gas state to a mist state by the heat exchanger, and the mist generation material in the mist state is neutralized by the alkaline neutralizer so as to be reduced.

[0013] In some embodiments, according to a fifth aspect, there is provided the air pollution control system according to the third or fourth aspect, further including: NO_x removal equipment which reduces nitrogen oxides from the flue gas; and a dry type electric dust collector which reduces particulates.

[0014] According to a sixth aspect of the present invention, there is provided an air pollution control method including bringing CO_2 in flue gas into contact with a CO_2 absorption liquid so as to absorb CO_2 from the flue gas and causing the CO_2 absorption liquid to emit CO_2 so as to recover the CO_2 and regenerate the CO_2 absorption liquid, the air pollution control method comprising, prior to bringing CO_2 in flue gas into contact with a CO_2 absorption liquid and causing the CO_2 absorption liquid to release CO_2: reducing particulates in flue gas; spraying calcium carbonate into the flue gas having a reduced amount of particulates; cooling the flue gas containing calcium carbonate to convert the mist generation material containing SO_3 from a gas state to a mist state; contacting and neutralizing mist generation material in the mist state with caucium carbotage sprayed into the flue gas, thereby reducing the amount of mist generation material in the flue gas; reducing sulfur oxides in the flue gas; and cooling the flue gas having a reduced amount of sulfur oxides to reduce the amount of sulfur oxides that remain in the flue gas; whereby scattering of the CO_2 absorption liquid as part of a mist generated by the mist generation material is alleviated by decreasing an amount of SO_3 mist to 3 ppm or less, wherein the CO_2 absorption liquid is an amine-based CO_2 absorption liquid.

[0015] According to a seventh aspect of the present invention, there is provided an air pollution control method including: on an upstream side of CO_2 recovery equipment for bringing CO_2 in flue gas into contact with a CO_2 absorption liquid so as to be absorbed and reduced, on a downstream side where particulates are reduced from the flue gas and on an upstream side of SO_x removal equipment for reducing sulfur oxides, converting a mist generation material in the flue gas from a gas state to a condensed state while decreasing a temperature of the flue gas so as to decrease an amount of the mist generation material in the flue gas introduced to the CO_2 recovery equipment to a predetermined amount or less.

[0016] In some embodiments, according to an eighth aspect, there is provided the air pollution control method according to the seventh aspect, wherein, on an upstream side of a heat exchanger, while the mist generation material in the flue gas is converted from the gas state to a mist state by spraying an alkaline neutralizer, the mist generation material in the mist state is neutralized by the alkaline neutralizer so as to be reduced.

[0017] According to the air pollution control system of some embodiments, since the dissolved salt spraying equipment is provided as the mist generation material reduction equipment before the introduction to the CO_2 recovery equipment, the amount of mist generation material in the flue gas when being introduced to the CO_2 absorber is significantly decreased. As a result, the amount of CO_2 absorption liquid that is entrained by mist and scatters to the outside of the system is decreased.

Therefore, the loss of the CO_2 absorption liquid that scatters to the outside of the system may be significantly decreased, and an increase in running cost during the air pollution control may be suppressed.

Brief Description of Drawings

[0018] FIG. 1 is a schematic diagram of an air pollution control system of an embodiment according to the present invention.

FIG. 2 is a conceptual diagram of a mechanism of mist generation.

FIG. 3-1 is a photograph illustrating a state where white smoke is decreased in a CO_2 absorber.

FIG. 3-2 is a photograph illustrating a state where white smoke is generated in the CO_2 absorber.

FIG. 4 is a schematic diagram of the air pollution control system according to a first embodiment.

FIG. 5 is a schematic diagram of another air pollution control system according to the first embodiment.

FIG. 6 is a schematic diagram of another air pollution control system according to a second embodiment.

Description of Embodiments

[0019] Hereinafter, the present invention will be described in detail with reference to the drawings. Note that, the present invention is not limited by embodiments and examples. In addition, components in the embodiments and the examples include those that may be easily assumed by those skilled in the art or are practically the same.

[0020] FIG. 1 is a schematic diagram of an air pollution control system of an embodiment according to the present invention.

As illustrated in FIG. 1, in an air pollution control system 10 of the embodiment according to the present invention, flue gas 12 from a boiler 11 is subjected to a reduction in nitrogen oxides (NO_x) from the flue gas 12 by NO_x removal equipment 13, and thereafter is first guided to an air heater AH to heat air supplied to the boiler 11. Thereafter, the flue gas 12 is introduced to a dry type electric dust collector 14 which is dust reduction equipment so as to reduce particulates. Next, the flue gas 12 is introduced to SO_x removal equipment 15 to reduce sulfur oxides (SO_x). Then, the flue gas 12 is cooled by a cooler 16, is thereafter introduced to CO_2 recovery equipment 17 to reduce carbon dioxide, and purified gas 18 is emitted from the top portion of a CO_2 absorber to the air which is outside the system. Note that, the particulates reduced by the electric dust collector 14 are subjected to an additional ash treatment 14a.

[0021] In the present invention, before introducing the flue gas 12 to the CO_2 recovery equipment 17, mist generation material reduction equipment 20 which reduces a mist generation material that is a generation source of mist generated in the CO_2 absorber of the CO_2 recovery equipment 17 is provided.

[0022] According to the air pollution control system according to the present invention, since the mist generation material reduction equipment 20 is provided before the introduction to the CO_2 recovery equipment 17, the amount of mist generation material in the flue gas 12 when being introduced to the CO_2 absorber of the CO_2 recovery equipment 17 is significantly decreased. As a result, the amount of CO_2 absorption liquid (hereinafter, also referred to as "absorption liquid") entrained by mist and discharged to the outside may be significantly decreased. As a result, the loss of the absorption liquid that scatters to the outside of the system is significantly decreased, and thus an unnecessary replenishment is eliminated, thereby suppressing an increase in running cost during the air pollution control.

[0023] The mist generation material reduced by the mist generation material reduction equipment 20 according to the present invention is SO_3 mist, nitric acid mist, hydrochloric acid mist, water vapor mist, or the like and is referred to as a material that becomes a mist generation factor in the CO_2 absorber. Note that, equipment that performs a reduction in a gas state before becoming mist is also included in the mist generation material reduction equipment 20 according to the present invention.

[0024] Since the flue gas 12 from the boiler 11 is in a high-temperature state, the mist generation material is present in a gas state at first. Thereafter, in a process of passing through the electric dust collector and the SO_x removal equipment, the flue gas is cooled, and thus the mist generation material changes from the gas state to a mist state.

The particle size of the mist of the mist generation material in the present invention is referred to as a size of equal to or smaller than 3.0 μm.

[0025] The form of mist generation and entraining of the absorption liquid in the CO_2 absorber of the CO_2 recovery equipment 17 will be described using FIGS. 2, 3-1, and 3-2.

FIG. 2 is a conceptual diagram of a mechanism of entraining of the absorption liquid by mist generation. FIG. 3-1 is a photograph illustrating a state where white smoke is decreased in the CO_2 absorber, and FIG. 3-2 is a photograph illustrating a state where white smoke is generated in the CO_2 absorber. Although, SO_3 mist is exemplified as the mist generation material in the description, descriptions with other kinds of mist will be the same. The flue gas 12 from the boiler 11 is subjected to a gas purifying treatment such as NO_x removal, a reduction in particulates, and SO_x removal, and the flue gas 12 is cooled by the cooler 16, resulting in a gas temperature of about 50°C. Since this temperature state is equal to or less than the acid dew point, there is SO_3 mist (for example, 0.1 to 1.0 μm).

An SO_3 mist 50 has SO_3 as a nucleus 51 and water vapor 52 that is incorporated into the periphery thereof.

[0026] In the CO_2 absorber, the absorption liquid is sprayed from nozzles and falls, and the falling absorption liquid and the flue gas are subjected to countercurrent contact such that CO_2 is absorbed by the absorption liquid.

On the other hand, the flue gas 12 is introduced from the lower side of the CO_2 absorber and is discharged to the upper side. Here, the SO_3 mist 50 is not absorbed by the absorption liquid and ascends along with the gas stream of the flue gas 12.

[0027] Here, in the CO_2 absorber, when the absorption liquid is supplied from the nozzles, the absorption liquid falls and a part of the absorption liquid and moisture evaporates, and thus a gaseous absorption liquid 41G and water vapor 42 are generated.

In addition, the amount of gaseous absorption liquid 41G and the water vapor 42 further increases as the temperature of the absorption liquid is increased due to, for example, the exothermic reaction of the absorption liquid when CO_2 is absorbed.

[0028] Then, the gaseous absorption liquid 41G and the water vapor 42 are incorporated into the SO_3 mist 50, resulting in a SO_3 mist (bloated mist) 53 including a bloated (for example, about 0.5 to 2.0 μm) absorption liquid.

[0029] As described above, the SO_3 mist 50 in the flue gas 12, before being introduced to the CO_2 recovery equipment 17, incorporates the gaseous absorption liquid 41G and the water vapor 42 in the CO_2 absorber, becomes the SO_3 mist 53 including the absorption liquid, and scatters from the top portion of the CO_2 absorber while being entrained by the flue gas 12. Therefore, the loss of the absorption liquid occurs.

[0030] The form of white smoke generation in the CO_2 absorber is illustrated in FIGS. 3-1 and 3-2.

FIG. 3-1 illustrates a case where the amount of mist generation material is decreased to a predetermined amount or less by providing the mist generation material reduction equipment 20 for the flue gas 12 introduced to the CO_2 absorber and a state where the scatting of the SO_3 mist (bloated mist) 53 including the absorption liquid in the CO_2 absorber is significantly reduced and thus generation of white smoke is suppressed. FIG. 3-2 illustrates a case where the flue gas 12 is introduced as it is without providing the mist generation material reduction equipment 20 for the flue gas 12 introduced to the CO_2 absorber and a state where the scatting of the SO_3 mist (bloated mist) 53 including the absorption liquid in the CO_2 absorber occurs and thus white smoke is generated.

[0031] That is, in the present invention, the mist generated in the CO_2 absorber is referred to as the SO_3 mist (bloated mist) 53 including the absorption liquid. Confirming the presence or absence of the generation of bloated mist is referred to as the presence or absence of generation of white smoke, and by suppressing the bloated mist in the CO_2 absorber, generation of white smoke is eliminated. Furthermore, the scattering of the absorption liquid is prevented.

[0032] In addition, regarding the bloated mist, as illustrated in FIG. 2, there may be cases where the gaseous absorption liquid 41G and the gaseous water vapor 42 are separately incorporated into the SO_3 mist 50 in the flue gas 12 in the CO_2 absorber to respectively form a SO_3 mist (bloated mist) 53A including the absorption liquid and a SO_3 mist (bloated mist) 53B including the water vapor.

Here, in the case of the mist (bloated mist) 53B including the water vapor, there is no loss of the absorption liquid. However, since generation of white smoke of the purified gas 18 to be discharged to the outside of a system occurs, a reduction in the mist generation material is also needed.

Therefore, according to the present invention, by providing the mist generation material reduction equipment 20 before introduction to the CO_2 recovery equipment 17, entraining of the CO_2 absorption liquid may be significantly reduced when the flue gas 12 from which CO_2 is reduced is discharged to the outside of the system, and an appropriate air pollution control may be performed.

[0033] Therefore, in the present invention, by providing the mist generation material reduction equipment 20 that reduces the mist generation material which is the generation source of the mist (the SO_3 mist including the absorption liquid which is the bloated mist) generated in the CO_2 absorber of the CO_2 recovery equipment 17 before introducing the flue gas 12 to the CO_2 recovery equipment 17, the loss of the absorption liquid that scatters to the outside of the system from the CO_2 absorber may be significantly decreased.

[0034] The mist generation material reduction equipment 20 may be provided on the upstream side of the dry type electric dust collector 14, between the dry type electric dust collector 14 and the SO_x removal equipment 15, or in either of the front and the rear of the cooler 16, or to be integrated into the cooler 16.

Here, before introducing the flue gas 12 to the CO_2 recovery equipment 17, it is preferable that the amount of SO_3 mist 50 be decreased to 3 ppm or less for prevention of white smoke and prevention of scattering of the absorption liquid in the CO_2 absorber. This is because when the amount of SO_3 mist 50 is decreased to 3 ppm or less, scattering is suppressed, and deterioration of, for example, an amine-based absorption liquid due to SO_3 is prevented.

[0035] According to the present invention, since the scattering of the absorption liquid is prevented and the deterioration of the absorption liquid is prevented, a decrease in the number of regeneration treatments performed in the regeneration equipment (reclaiming equipment) for the absorption liquid may be achieved, and the loss of the absorption liquid is further significantly decreased, so that a decrease in the amount of the replenished absorption liquid may be achieved. Therefore, the system efficiency of the air pollution control system may be significantly enhanced.

[0036] Note that, in this embodiment, the electric dust collector is exemplified as the dust reduction equipment in the description. However, the present invention is not limited to this as long as particulates are reduced from the flue gas 12, and besides the electric dust collector, for example, a bag filter or a venturi scrubber may be exemplified.

[0037] In the following embodiment, a specific form of the mist generation material reduction equipment that reduces the mist generation material will be described.

First Embodiment

[0038] The air pollution control system including the CO_2 recovery equipment according to a first embodiment of the present invention will be described with reference to the drawings. FIG. 4 is a schematic diagram of the air pollution control system according to the first embodiment. FIG. 5 is a schematic diagram of another air pollution control system according to the first embodiment. Note that, in the following embodiment, SO_3 is exemplified as the mist generation material in the description, but the present invention is not limited thereto.

As illustrated in FIG. 4, an air pollution control system 10A according to the first embodiment includes the

NO_x removal equipment 13 which reduces nitrogen oxides from the flue gas 12 from the boiler (for example, coal-fired boiler) 11, the electric dust collector 14 which is provided on the downstream side of the NO_x removal equipment 13 and reduces particulates from the flue gas 12, the SO_x removal equipment 15 which is provided on the downstream side of the electric dust collector 14 and reduces sulfur oxides from the flue gas 12, the cooler 16 which is provided on the downstream side of the SO_x removal equipment 15 and has a cooling unit 16a that decreases the gas temperature, and the CO_2 recovery equipment 17 which includes an absorber 17A that brings CO_2 in the flue gas 12 into contact with the absorption liquid so as to be reduced and a regenerator 17B that causes the absorption liquid to emit CO_2 to recover the CO_2 and regenerate the absorption liquid.

[0039] In this embodiment, before introducing the SO_3 mist to the CO_2 recovery equipment 17, calcium carbonate spraying equipment 31 is provided between the electric dust collector 14 and the SO_x removal equipment 15 to spray calcium carbonate ($CaCO_3$) into the flue gas 12. In addition, on the upstream side of the SO_x removal equipment 15 which is on the downstream side where spraying is performed, a heat exchanger 32 which decreases the flue gas temperature is provided. The calcium carbonate spraying equipment 31 and the heat exchanger 32 according to this embodiment function as the mist generation material reduction equipment 20.

[0040] On the upstream side of the SO_x removal equipment 15, as the temperature of the flue gas 12 is decreased to a sulfuric acid dew point or less by the heat exchanger 32, gaseous SO_3 is converted to mist-like SO_3, and the mist-like SO_3 is neutralized by $CaCO_3$ (limestone) sprayed into the flue gas 12, thereby reducing the mist-like SO_3 from the flue gas 12.

[0041] In this embodiment, as a result of converting SO_3 which is the mist generation material in the flue gas 12 from the gas state to the mist state and reducing the mist-like mist generation material, a decrease in the amount of the SO_3 mist 50 introduced to the CO_2 recovery equipment 17 is achieved. Therefore, the generation of white smoke of the purified gas 18 discharged from the CO_2 absorber 17A, which is caused by the mist, is suppressed, and the entraining of absorption liquid 41 is suppressed. As a result, an air pollution control system in which the loss of the absorption liquid 41 is significantly decreased may be provided.

[0042] In addition, the flue gas 12 from which particulates are reduced in the electric dust collector 14 is subjected to a reduction in sulfur oxides from the flue gas 12 in the SO_x removal equipment 15, the reduced sulfur oxides are supplied with limestone ($CaCO_3$) 15a and oxidation air 15b to become gypsum 15c through a limestone-gypsum method, and desulfurized waste water 15d is separately treated. Note that, in the figures, reference numerals 17a, 17b, 17c, 17d, 17e, and 17f denote a reboiler, saturated water vapor, condensed water, a separation drum, recovered CO_2, and an absorption liquid heat exchanger, respectively.

[0043] The flue gas 12 desulfurized by the SO_x removal equipment 15 is cooled by the cooler 16 to cause the flue gas temperature to be 50°C or less, and is introduced to the CO_2 recovery equipment 17 including the absorber 17A and the regenerator 17B. Here, CO_2 in the flue gas 12 is reduced by, for example, the amine-based absorption liquid 41. At this time, in this embodiment, as a result of reducing SO_3 in the gas state which is the mist generation material in the flue gas 12, a decrease in the amount of the SO_3 mist introduced to the CO_2 recovery equipment 17 is achieved. Therefore, the generation of white smoke of the purified gas 18 discharged from the absorber 17A, which is caused by the mist, is suppressed, and the entraining of the absorption liquid 41 is suppressed.

As a result, an air pollution control system in which there is no loss of the absorption liquid may be provided.

[0044] Here, in this embodiment, the amine-based absorption liquid is exemplified as the absorption liquid. However, the absorption liquid of the present invention is not limited to the amine-based absorption liquid. As the absorption liquid, besides the amine-based absorption liquid, for example, an amino acid-based absorption liquid, an ionic liquid absorption liquid, a hot potassium carbonate absorption liquid made of potassium carbonate and amines, and the like may be exemplified.

[0045] FIG. 5 is a schematic diagram of an air pollution control system of a modified example of the first embodiment. In the cooler 16 illustrated in FIG. 4, the flue gas 12 is cooled. However, as illustrated in FIG. 5, an air pollution control system 10B is provided with a finishing SO_x removal unit 16b at the lower portion of the cooler 16 and supplies the limestone ($CaCO_3$) 15a and the oxidation air 15b to form the gypsum 15c through the limestone-gypsum method. Accordingly, sulfur oxides that remain in the flue gas 12 from the SO_x removal equipment 15 is reduced, and thus the SO_x removal efficiency is further enhanced. In addition, a strong alkaline agent such as sodium hydroxide (NaOH) may be added along with the limestone.

In this embodiment, in the finishing SO_x removal unit

16b, a liquid column type is used as a method of supplying a SO_x removal absorption liquid. However, the present invention is not limited thereto, and any of sprinkling type, jet type, and filling type may also be used.

[0046] Here, as the SO_x removal absorption liquid used in the finishing SO_x removal unit 16b, besides the limestone ($CaCO_3$), a strong alkaline agent such as NaOH, Na_2CO_3, $NaHCO_3$, $Ca(OH)_2$, or $Mg(OH)_2$ may be exemplified. By using the strong alkaline agent, further enhancement of the SO_x removal performance may be achieved, and this is particularly effective in a case where the flue gas 12 having a high sulfur oxide concentration is introduced, thereby decreasing the concentration of sulfur oxides in the flue gas 12 introduced to the CO_2 recovery equipment 17 to an extremely low concentration. The SO_x removal performance is increased compared to the limestone-gypsum method. Therefore, even in a case where the concentration of sulfur oxides in the introduced flue gas 12 is high, favorable SO_x removal performance is exhibited, which is preferable.

[0047] As described above in the embodiments, according to the present invention, since the calcium carbonate spraying equipment 31 and the heat exchanger 32 are provided as the mist generation material reduction equipment 20, an air pollution control system in which the absorption liquid 41 is not entrained when the flue gas from which CO_2 is reduced is discharged to the outside may be provided.

Second Embodiment

[0048] An air pollution control system including the CO_2 recovery equipment according to a second embodiment of the present invention will be described with reference to the drawings. FIG. 6 is a schematic diagram of the air pollution control system according to the second embodiment. Note that, elements that are the same as those of the air pollution control system 10A according to the first embodiment are denoted by the same reference numerals, and overlapping description will not be repeated.

As illustrated in FIG. 6, an air pollution control system 10C according to the second embodiment includes the NO_x removal equipment 13 which reduces nitrogen oxides from the flue gas 12 from the boiler (for example, coal-fired boiler) 11, the electric dust collector 14 which is provided on the downstream side of the NO_x removal equipment 13 and reduces particulates from the flue gas 12, the SO_x removal equipment 15 which is provided on the downstream side of the electric dust collector 14 and reduces sulfur oxides from the flue gas 12, a heat exchanger which is provided on the upstream side of the SO_x removal equipment and decreases the flue gas temperature to an acid dew point or less, the cooler 16 which is provided on the downstream side of the SO_x removal equipment 15 and decreases the gas temperature, and the CO_2 recovery equipment 17 which includes the absorber 17A that brings CO_2 in the flue gas 12 into contact with the absorption liquid so as to be reduced and the regenerator 17B that causes the absorption liquid to emit CO_2 to recover CO_2 and regenerate the absorption liquid.

[0049] In this embodiment, on the upstream side of the SO_x removal equipment 15, the heat exchanger 32 is provided to cool the flue gas temperature to the acid dew point or less, thereby converting the mist generation material in the flue gas from the gas state to the condensed state and reducing the mist generation material.

[0050] Here, it is preferable that the heat exchanger 32 not be a general heat exchange member made of steel but be made of a corrosion-resistant material. This is because when SO_3 which is the mist generation material is changed from the gas state to the condensed state (liquid state), resistance to corrosion due to sulfurous acid or sulfuric acid is necessary for long-term stable operation.

[0051] Here, as the corrosion-resistant material in the present invention, an acid-resistant organic material or inorganic material may be used. For example, as the organic material, "Teflon (a registered trademark)" such as polytetrafluoroethylene (PTFE) may be exemplified.

In this case, the constituent member of the heat exchanger may be treated by coating with the corrosion-resistant material, and the constituent member itself may be manufactured of a corrosion-resistant material.

[0052] As a result, it is unnecessary to perform cooling in the heat exchanger 32 as in the first embodiment, convert the gaseous SO_3 to the mist-like SO_3, neutralize the mist-like SO_3 by $CaCO_3$ (limestone) sprayed into the flue gas 12 on the upstream side of the heat exchanger 32, and reduce the mist-like SO_3 from the flue gas 12.

Therefore, in this embodiment, the heat exchanger 32 functions as the mist generation material reduction equipment 20.

[0053] In this embodiment, as a result of converting SO_3 which is the mist generation material in the flue gas 12 from the gas state to the condensed state (liquid state) and reducing the mist-like mist generation material, a decrease in the amount of the SO_3 mist 50 introduced to the CO_2 recovery equipment 17 is achieved. Therefore, the generation of white smoke of the purified gas 18 discharged from the CO_2 absorber 17A, which is caused by the mist, is suppressed, and the entraining of the absorption liquid 41 is suppressed. As a result, an air pollution control system in which the loss of the absorption liquid 41 is significantly decreased may be provided. Note that, the condensate which is condensed is separately recovered from the heat exchanger.

[0054] Here, it is preferable that the cooling temperature of the flue gas in the heat exchanger 32 be equal to or lower than the acid dew point. However, more preferably, the temperature of the flue gas after heat exchange may be cooled to 100 to 60°C.

According to the related art, in terms of corrosiveness of the heat exchanger, the flue gas temperature after heat exchange is 100 to 85°C. On the other hand, since cooling to 85°C or less is achieved, SO_3 which is the mist generation material may be more actively condensed and reduced.

[0055] The flue gas 12 desulfurized by the SO_x removal equipment 15 is cooled by the cooler 16 to cause the flue gas temperature to be 50°C or less, and is introduced to the CO_2 recovery equipment 17 including the absorber 17A and the regenerator 17B. Here, CO_2 in the flue gas 12 is reduced by, for example, the amine-based absorption liquid 41. At this time, in this embodiment, as a result of reducing SO_3 in the condensed state which is the mist generation material in the flue gas 12, a decrease in the amount of the SO_3 mist introduced to the CO_2 recovery equipment 17 is achieved. Therefore, the generation of white smoke of the purified gas 18 discharged from the absorber 17A, which is caused by the mist, is suppressed, and the entraining of the absorption liquid 41 is suppressed.

As a result, an air pollution control system in which there is no loss of the absorption liquid may be provided.

[0056] In addition, alkaline neutralizer spraying equipment which sprays an alkaline neutralizer between the dust reduction equipment and the heat exchanger may be provided, the flue gas 12 may be cooled by the heat exchanger to convert the mist generation material in the flue gas 12 from the gas state to the mist state, and the mist generation material in the mist state may be neutralized by the alkaline neutralizer so as to be reduced.

Accordingly, by the synergy effect in the reduction in the mist generation material through cooling in the heat exchanger and the neutralization reaction of the mist-like SO_3 using the alkaline neutralizer, the efficiency of reducing the mist-like SO_3 from the flue gas 12 may be enhanced.

[0057] Here, as the alkaline neutralizer, besides calcium carbonate ($CaCO_3$) exemplified in the first embodiment, for example, calcium oxide (CaO), calcium hydroxide ($Ca(OH)_2$), and the like may be exemplified.

[0058] As described above in the embodiments, according to the present invention, since the heat exchanger 32 having corrosion resistance is provided as the mist generation material reduction equipment 20, in the previous step in which the flue gas 12 is introduced to the CO_2 recovery equipment, the mist generation material is condensed and reduced. Therefore, an air pollution control system in which the absorption liquid 41 is not entrained when the flue gas from which CO_2 is reduced is discharged from the CO_2 recovery equipment to the outside may be provided.

Reference Signs List

[0059] 10, 10A to 10C AIR POLLUTION CONTROL SYSTEM

11 BOILER

12 FLUE GAS

13 NO_x REMOVAL EQUIPMENT

14 ELECTRIC DUST COLLECTOR

15 SO_x REMOVAL EQUIPMENT

16 COOLER

16a COOLING UNIT

16b FINISHING SO_x REMOVAL UNIT

17 CO_2 RECOVERY EQUIPMENT

17A ABSORBER

17B REGENERATOR

18 PURIFIED GAS

20 MIST GENERATION MATERIAL REDUCTION EQUIPMENT

31 CALCIUM CARBONATE SPRAYING EQUIPMENT

32 HEAT EXCHANGER

CLAIMS:

1. An air pollution control system including a CO_2 recovery equipment having an absorber for bringing CO_2 in flue gas from a boiler into contact with a CO_2 absorption liquid so as to absorb the CO_2 from the flue gas and a regenerator for causing the CO_2 absorption liquid to emit CO_2 so as to recover the CO_2 and regenerate the CO_2 absorption liquid,

the air pollution control system comprising:

dust reduction equipment for reducing particulates in flue gas;

calcium carbonate spraying equipment provided downstream of the dust reduction equipment and for spraying calcium carbonate into the flue gas;

a heat exchanger provided downstream of the calcium carbonate spraying equipment and for cooling the flue gas so as to convert mist generation material containing SO_3 from a gaseous state to a mist state so that mist generation material in the mist state contacts calcium carbonate sprayed into the flue gas and is nurtralized, thereby reducing the amount of mist generation material in the flue gas;

SO_x removal equipment provided downstream of the heat exchanger and for reducing sulfur oxides in the flue gas; and

a cooler provided downstream of the SO_x removal equipment and upstream of the CO_2 recovery equipment, for reducing sulfur oxides that remain in the flue gas and for decreasing gas temperature;

whereby scattering of the CO_2 absorption liquid as part of a mist generated by the mist generation material is alleviated by decreasing an amount of SO_3 mist to 3 ppm or less, wherin the CO_2 absorption liquid is an amine-based CO_2 absorption liquid.

2. The air pollution control system according to claim 1, further comprising NO_x removal equipment for reducing nitrogen oxides in the flue gas.

3. An air pollution control method including bringing CO_2 in flue gas into contact with a CO_2 absorption liquid so as to absorb CO_2 from the flue gas and causing the CO_2 absorption liquid to emit CO_2 so as to recover the CO_2 and regenerate the CO_2 absorption liquid,

the air pollution control method comprising, prior to bringing CO_2 in flue gas into contact with a CO_2 absorption liquid and causing the CO_2 absorption liquid to release CO_2:

reducing particulates in flue gas;

spraying calcium carbonate into the flue gas having a reduced amount of particulates;

cooling the flue gas containing calcium carbonate to convert the mist generation material containing SO_3 from a gas state to a mist state;

contacting and neutralizing mist generation material in the mist state with caucium carbotage sprayed into the flue gas, thereby reducing the amount of mist generation material in the flue gas;

reducing sulfur oxides in the flue gas; and

cooling the flue gas having a reduced amount of sulfur oxides to reduce the amount of sulfur oxides that remain in the flue gas;

whereby scattering of the CO_2 absorption liquid as part of a mist generated by the mist generation material is alleviated by decreasing an amount of SO_3 mist to 3 ppm or less, wherein the CO_2 absorption liquid is an amine-based CO_2 absorption liquid.

FIG.1

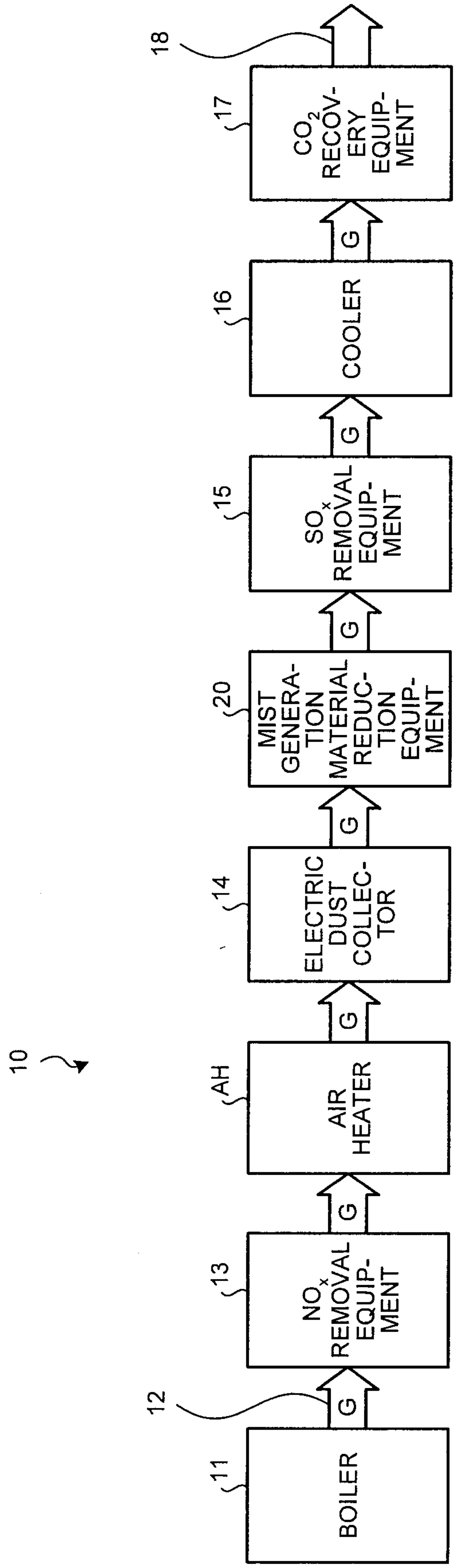

10
11
BOILER
12
G
13
NO_x REMOVAL EQUIP-MENT
G
AH
AIR HEATER
G
14
ELECTRIC DUST COLLEC-TOR
G
20
MIST GENERA-TION MATERIAL REDUC-TION EQUIP-MENT
G
15
SO_x REMOVAL EQUIP-MENT
G
16
COOLER
G
17
CO_2 RECOV-ERY EQUIP-MENT
18

FIG.2

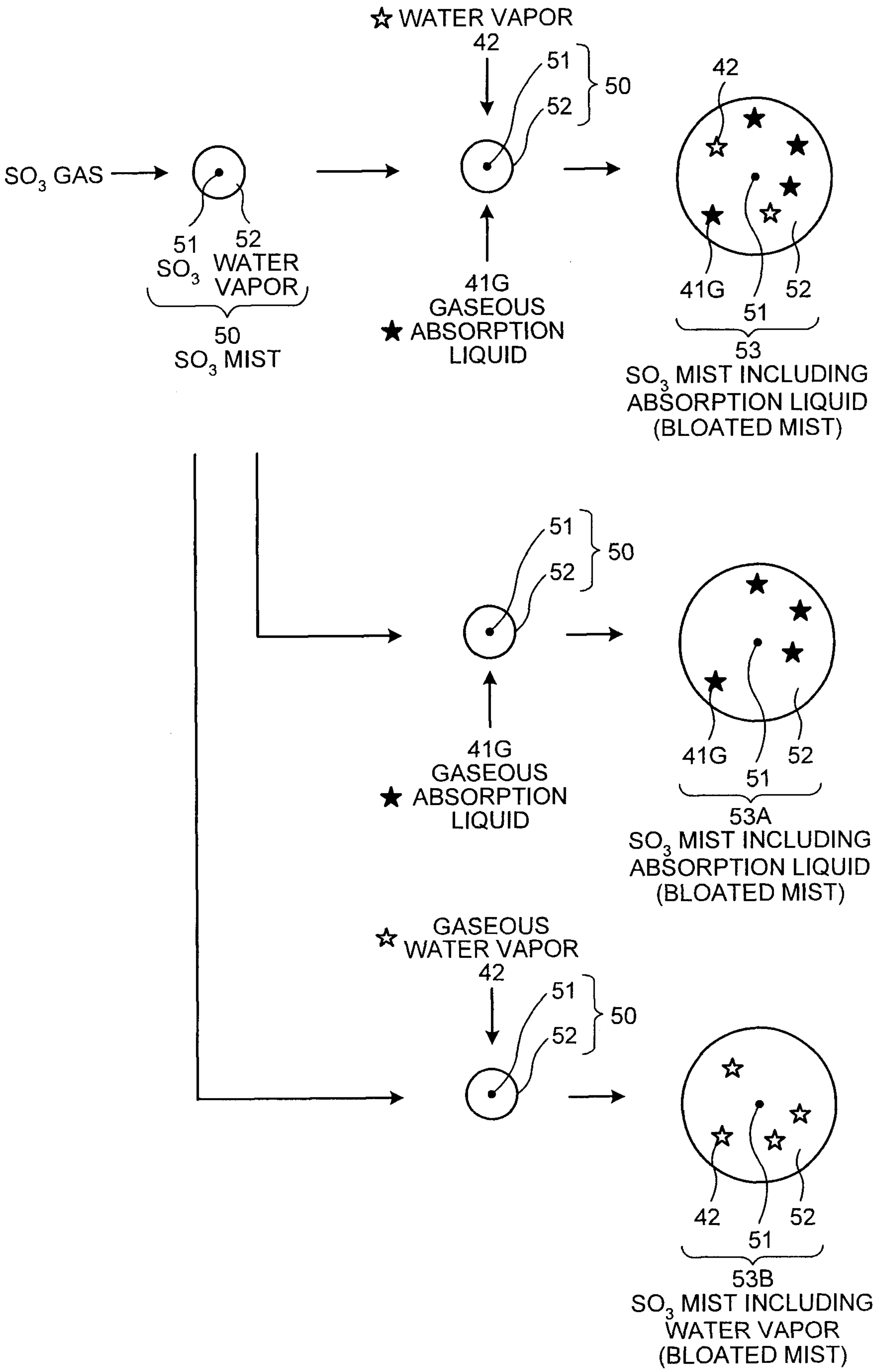

☆ WATER VAPOR
42
51
52
50
SO3 GAS
51
SO3
52
WATER VAPOR
50
SO3 MIST
41G
GASEOUS
★ ABSORPTION LIQUID
42
41G
52
51
53
SO3 MIST INCLUDING ABSORPTION LIQUID (BLOATED MIST)
51
52
50
41G
GASEOUS
★ ABSORPTION LIQUID
41G
52
51
53A
SO3 MIST INCLUDING ABSORPTION LIQUID (BLOATED MIST)
☆ GASEOUS WATER VAPOR
42
51
52
50
42
52
51
53B
SO3 MIST INCLUDING WATER VAPOR (BLOATED MIST)

FIG.3-1

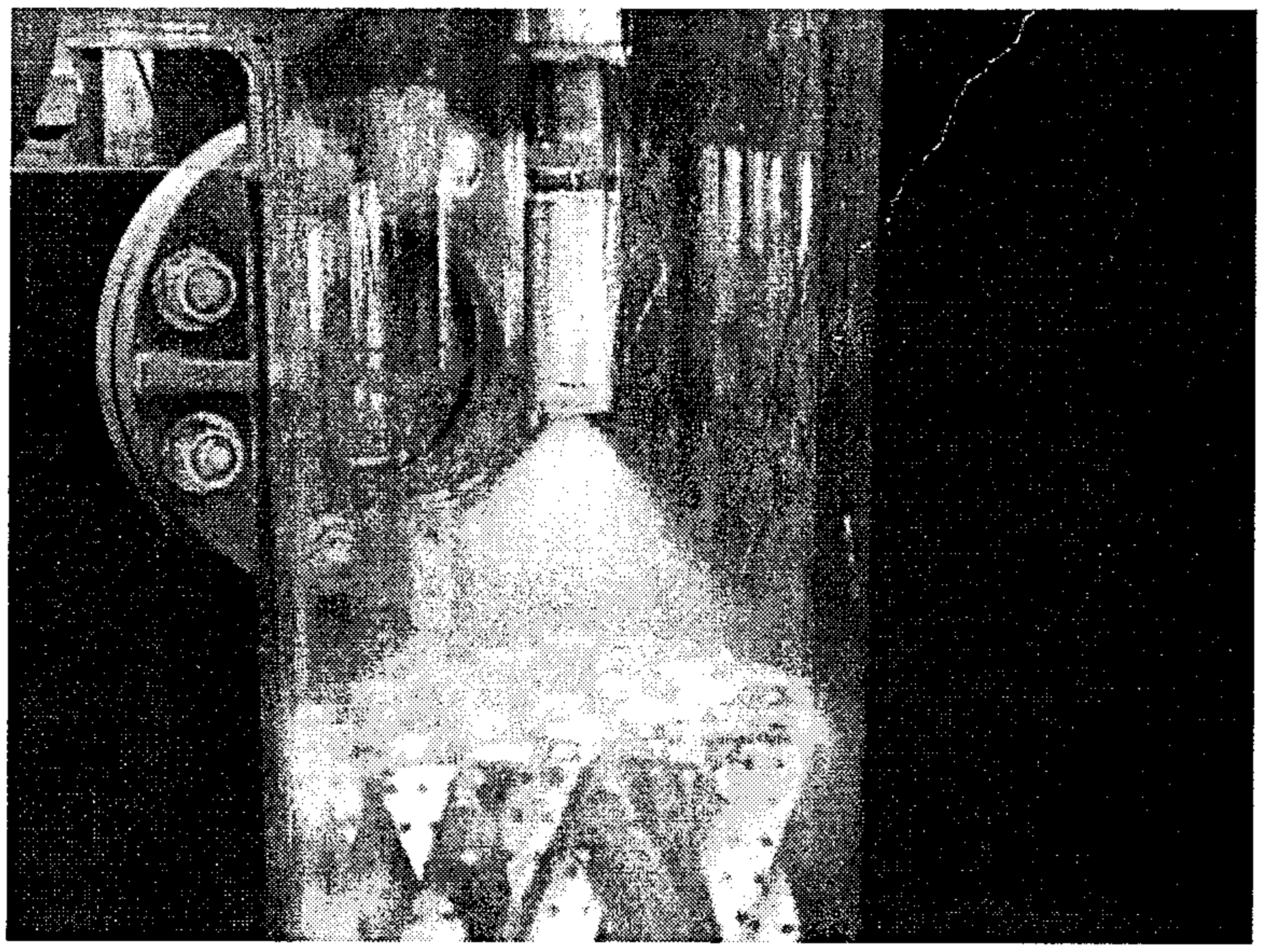


FIG.3-2

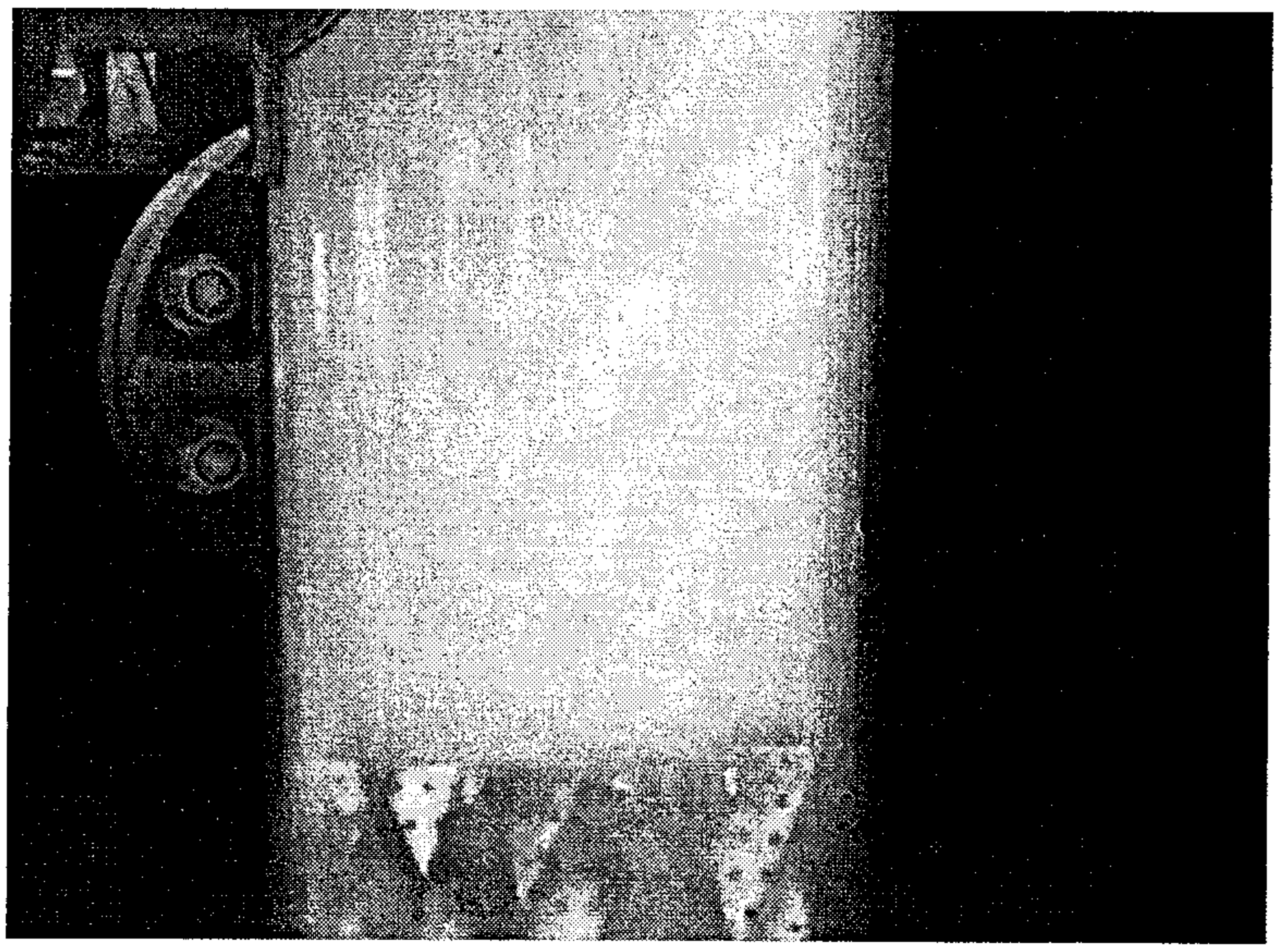


FIG.4

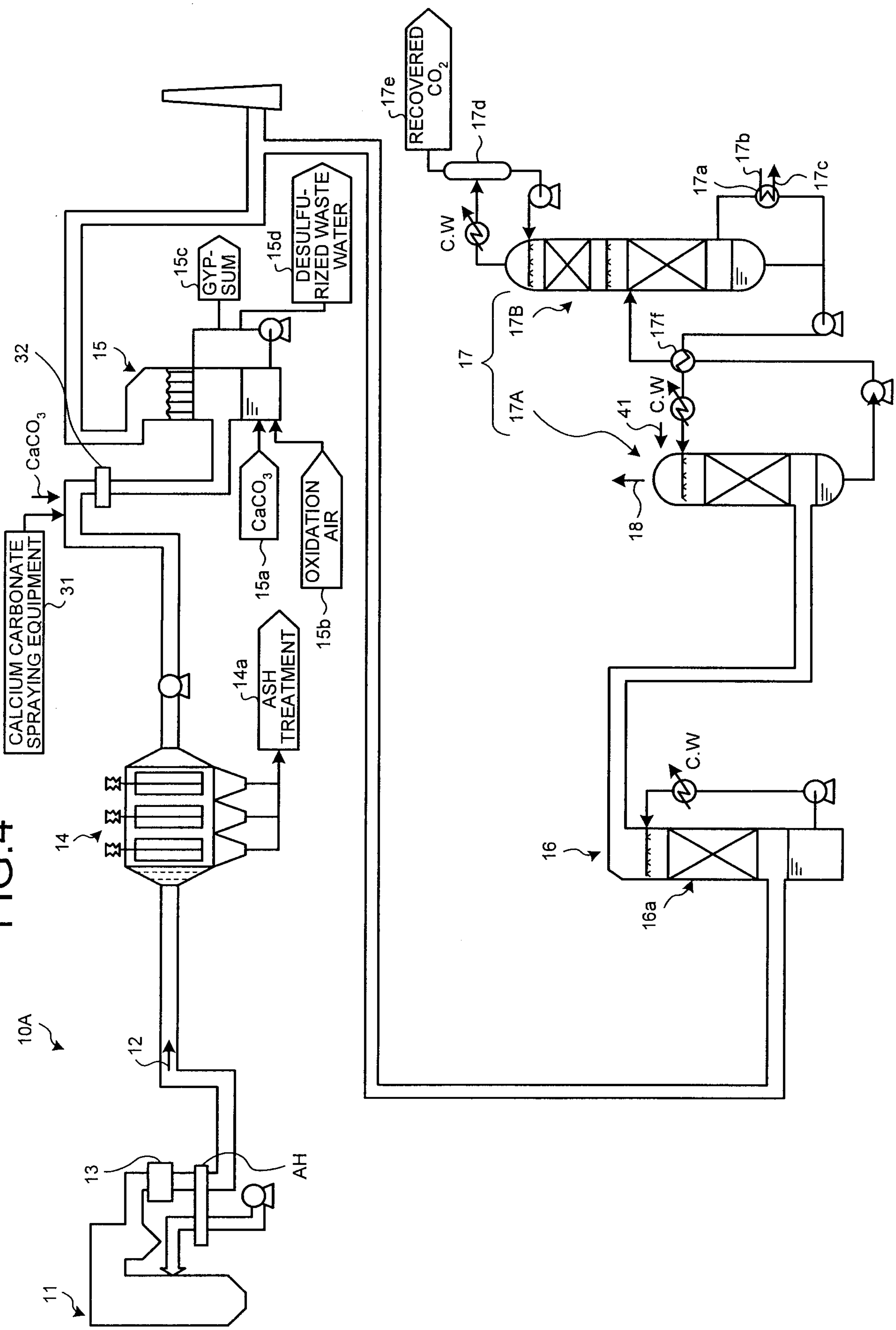

10A
11
13
AH
12
14
14a
ASH TREATMENT
CALCIUM CARBONATE SPRAYING EQUIPMENT
31
32
$CaCO_3$
15
15a
$CaCO_3$
15b
OXIDATION AIR
15c
GYP-SUM
15d
DESULFU-RIZED WASTE WATER
16
16a
C.W
17
17A
17B
17a
17b
17c
17d
17e
RECOVERED CO_2
17f
18
41
C.W
C.W

FIG.5

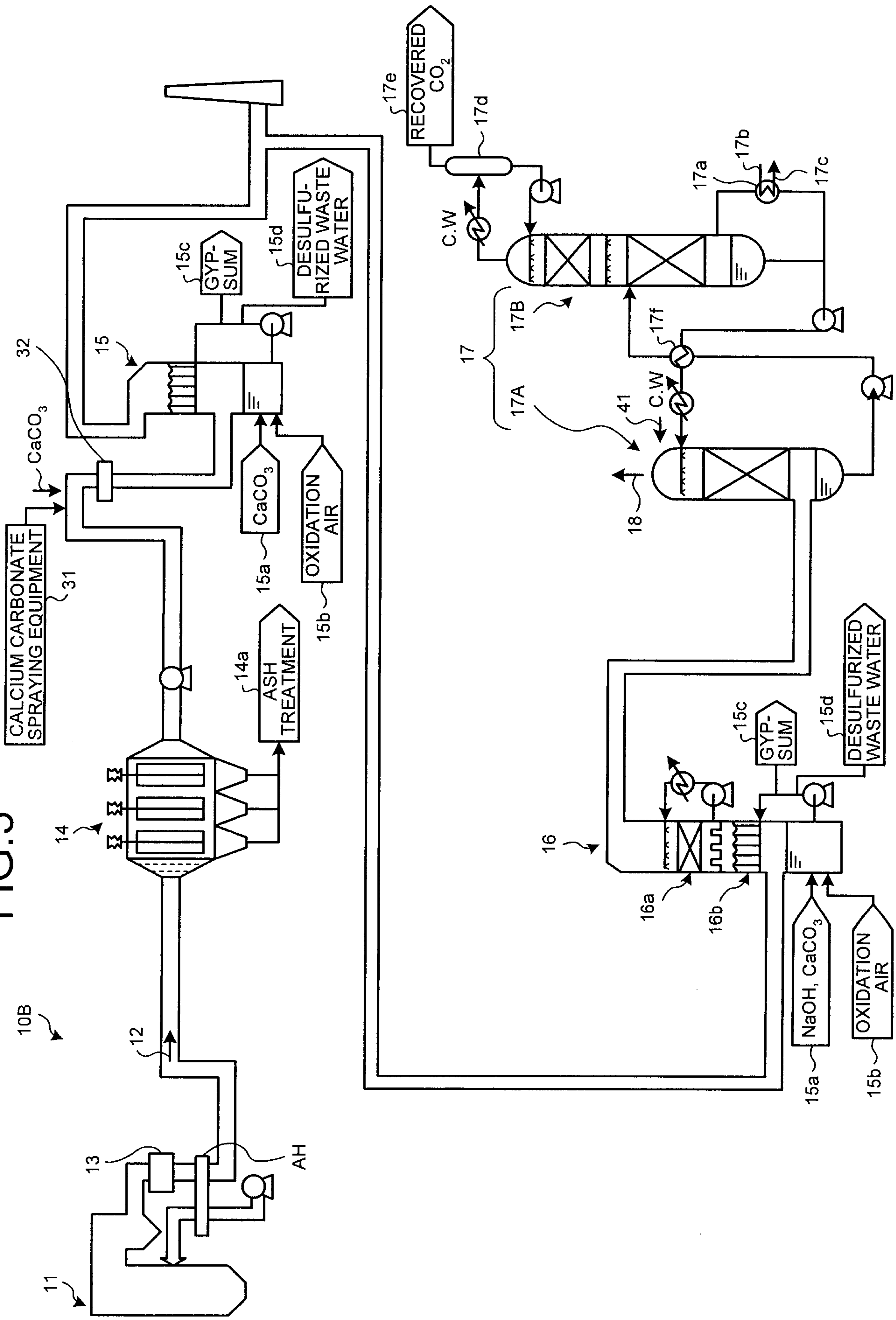
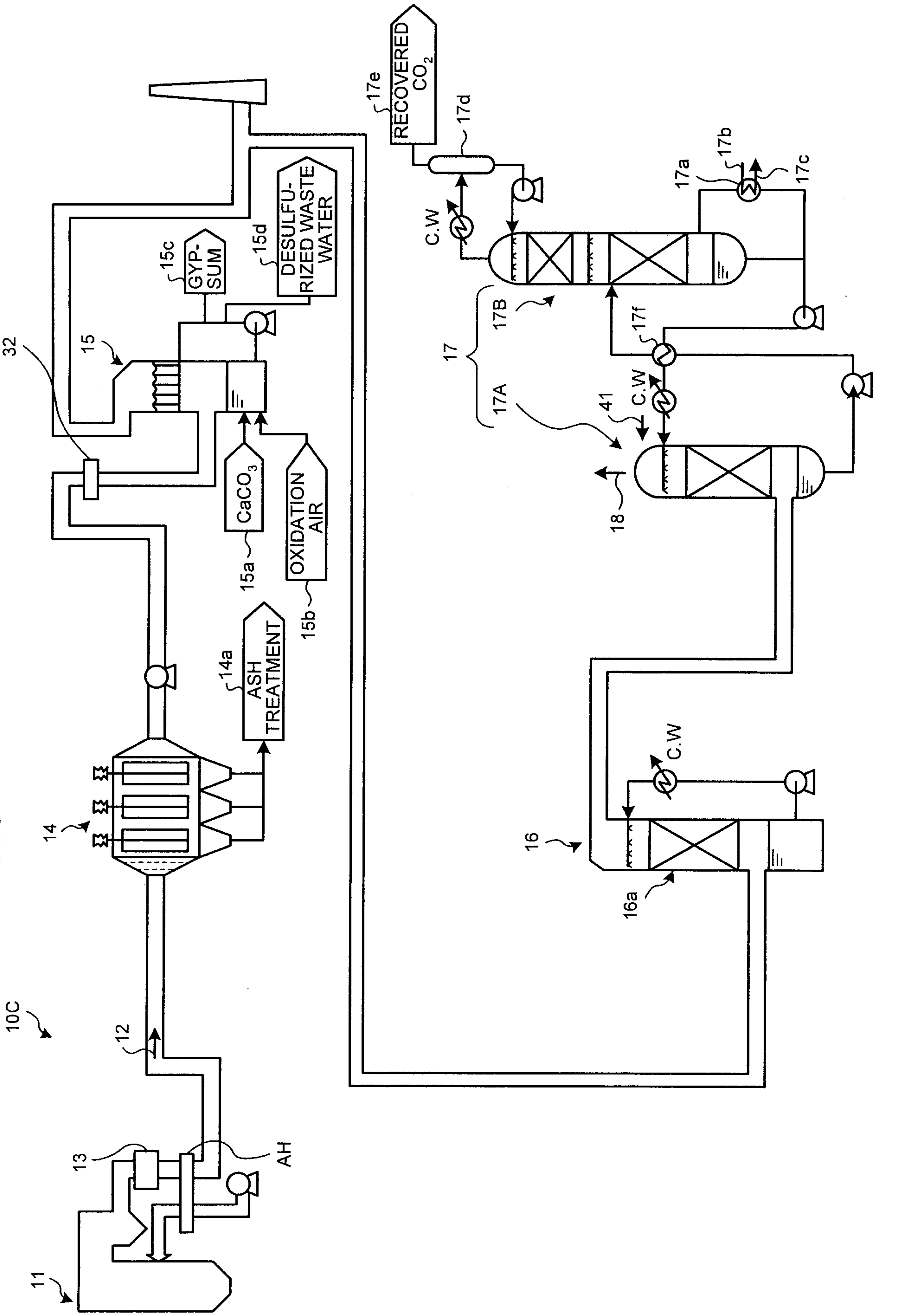
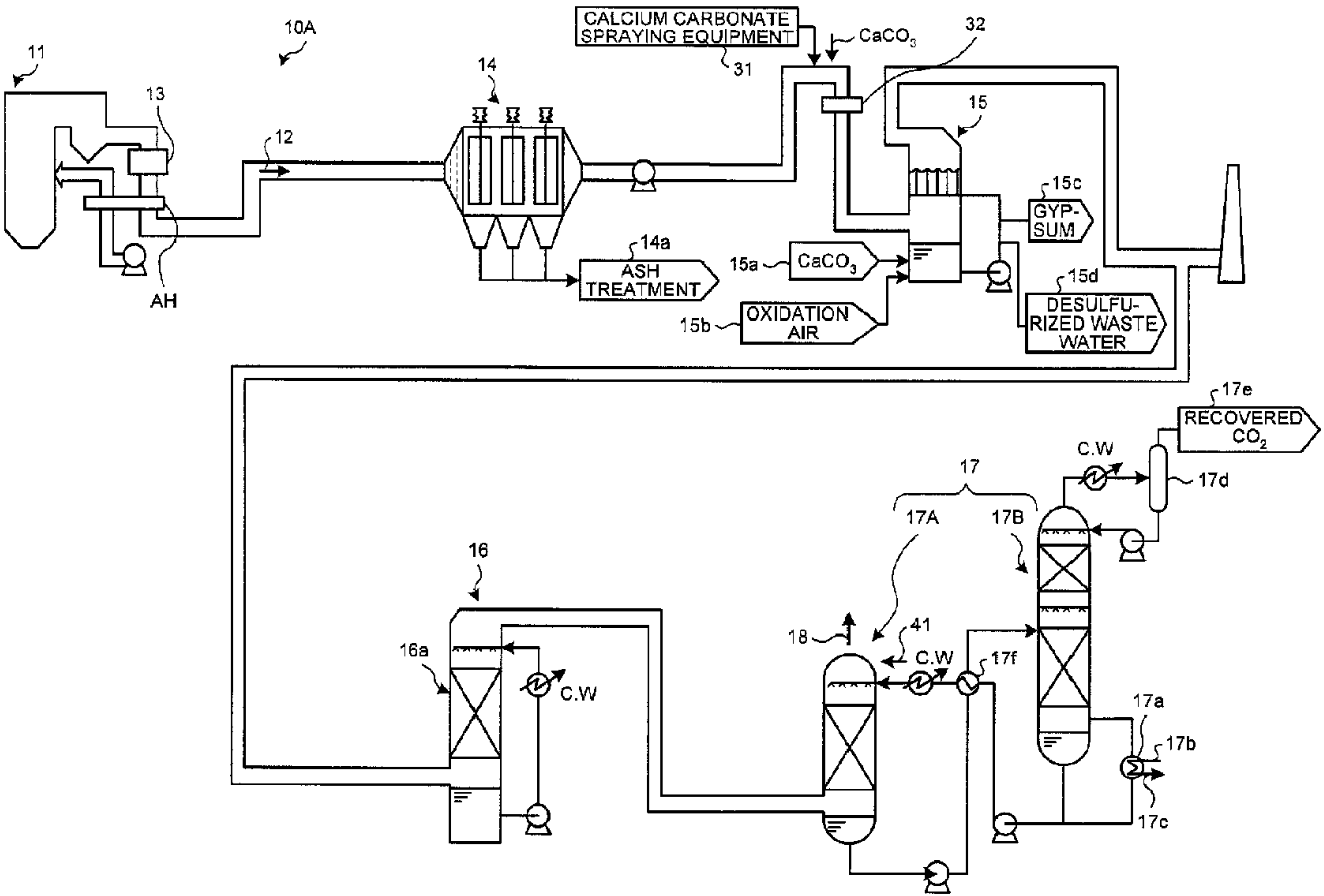

10B
11
13
AH
12
14
14a
ASH TREATMENT
CALCIUM CARBONATE SPRAYING EQUIPMENT
31
32
$CaCO_3$
15
15a
$CaCO_3$
15b
OXIDATION AIR
15c
GYP-SUM
15d
DESULFU-RIZED WASTE WATER
16
16a
16b
15a
NaOH, $CaCO_3$
15b
OXIDATION AIR
15c
GYP-SUM
15d
DESULFURIZED WASTE WATER
17
17A
17B
17a
17b
17c
17d
17e
17f
RECOVERED CO_2
C.W
C.W
41
18

FIG.6


10C
11
13
AH
12
14
14a
ASH TREATMENT
15a
$CaCO_3$
15b
OXIDATION AIR
32
15
15c
GYP-SUM
15d
DESULFU-RIZED WASTE WATER
16
16a
C.W
18
41
C.W
17
17A
17B
17f
C.W
17a
17b
17c
17d
17e
RECOVERED CO_2


10A
11
13
12
AH
14
14a
ASH TREATMENT
CALCIUM CARBONATE SPRAYING EQUIPMENT
31
CaCO3
32
15
15c
GYP-SUM
15a
CaCO3
15b
OXIDATION AIR
15d
DESULFU-RIZED WASTE WATER
17e
RECOVERED CO2
C.W
17d
17
17A
17B
16
16a
C.W
18
41
C.W
17f
17a
17b
17c