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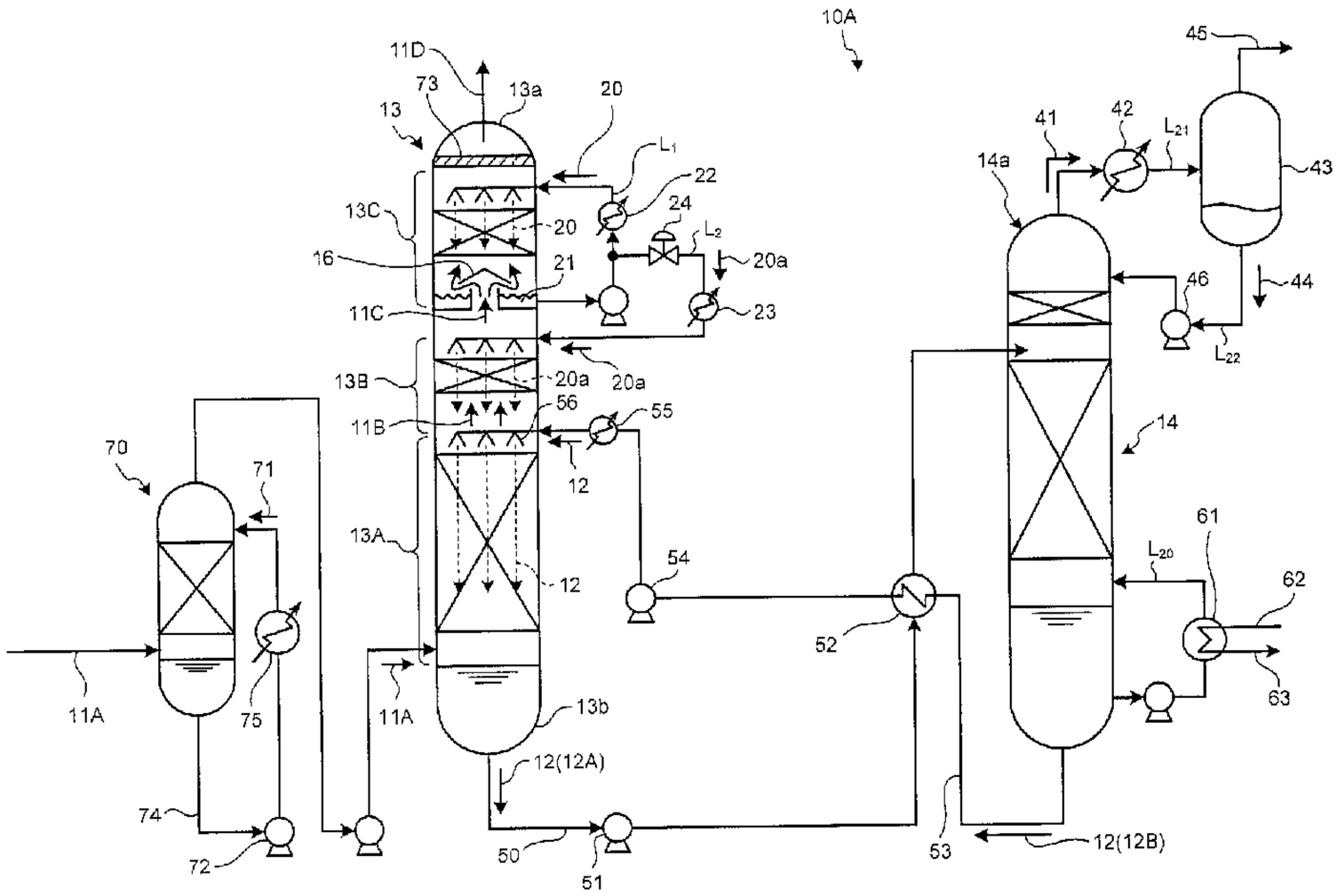
(54) Title: CO_2 RECOVERY UNIT AND CO_2 RECOVERY METHOD



(57) Abrégé/Abstract:
A CO_2 recovery device for recovery and removal of CO_2 in CO_2-containing exhaust gas (11A) that contains CO_2 using a CO_2 -absorbing liquid (12) inside a CO_2 absorption tower (13), wherein the CO_2 absorption tower (13) is obtained by being provided with: a CO_2-absorbing unit (13A) for absorbing CO_2 in CO_2-containing exhaust gas; a main aqueous cleaning unit (13C), which is provided on the gas flow downstream side of the CO_2-absorbing unit (13A) and which uses rinsing water (20) to cool the decarbonated exhaust gas while using the rinsing water (20) to recover the accompanying CO_2-absorbing liquid; and a preliminary aqueous cleaning unit (13B) provided between the CO_2-absorbing unit (13A) and the main aqueous cleaning unit (13C). A portion (20a) of the rinsing water (20) containing the CO_2-absorbing liquid that is circulating in the main aqueous cleaning unit (13C) is extracted and used for pre-rinsing in the preliminary aqueous cleaning unit (13B) and the pre-rinsing water is made to flow down directly to the CO_2-absorbing unit (13A) side and merge with the CO_2-absorbing liquid (12).

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Abstract

A CO_2 recovery unit (10A; 10B; 10C) for recovery and removal of CO_2 in a CO_2-containing flue gas 11A that contains CO_2 using a CO_2-absorbent 12 within a CO_2 absorber 13 is provided. The CO_2 absorber 13 includes a CO_2-absorbing unit 13A for the absorption of CO_2 in a CO_2-containing flue gas, a main water rinsing unit 13C that is provided on a gas flow downstream side of the CO_2-absorbing unit 13A and that uses rinsing water 20 to recover the accompanying CO_2-absorbent while cooling decarbonated flue gas, and a preliminary water rinsing unit 13B provided between the CO_2-absorbing unit 13A and the main water rinsing unit 13C. A portion 20a of the rinsing water 20 containing the CO_2-absorbent that is circulated in the main water rinsing unit 13C is withdrawn and is subjected to preliminary water rinsing in the preliminary water rinsing unit 13B. The preliminary rinsing water is allowed to meet with a CO_2-absorbent 12 while allowing the rinsing water to directly flow down on the CO_2-absorbing unit 13A side.

DESCRIPTION

CO_2 RECOVERY UNIT AND CO_2 RECOVERY METHOD

Field

[0001] The present invention relates to a CO_2 recovery unit and a CO_2 recovery method that reduce the concentration of basic amine compounds which remain in and are released from a decarbonated flue gas from which CO_2 has been removed by contact with an absorbent.

Background

[0002] The greenhouse effect of CO_2 has been pointed out as a cause of global warming, and there is a pressing need to take a measure against the greenhouse effect internationally from the viewpoint of saving the global environment. CO_2 emission sources include various fields of human activity where fossil fuels are burned, and there is a tendency towards an ever-increasing demand for the suppression of CO_2 emissions. This has led to an energetic study on a method, for power generation facilities such as thermal power plants and the like that use a large amount of fossil fuels, that includes bringing a flue gas from boilers into contact with an amine-based absorbent such as an aqueous amine compound solution to remove and recover CO_2 from the flue gas.

[0003] When CO_2 is recovered using the absorbent from the flue gas, amine compounds disadvantageously accompany a decarbonated flue gas from which CO_2 has been recovered. The amount of the amine compound released together with the decarbonated flue gas should be reduced from the viewpoint of preventing the occurrence of air pollution from amine compounds.

[0004] Patent Literature 1 discloses a conventional method that provides a water rinsing unit in a plurality of stages that recover amine compounds accompanying a

decarbonated flue gas by subjecting a decarbonated flue gas, from which CO_2 has been absorbed and removed by gas-liquid contact with an absorbent, to gas-liquid contact with rinsing water, and successively performing treatment for the recovery of amine compounds accompanying the decarbonated flue gas in the water rinsing unit in the plurality of stages. The rinsing water used in Patent Literature 1 is condensed water obtained by condensing and separating the water contained in CO_2 in such a treatment that CO_2 is removed from an amine-based absorbent with CO_2 absorbed therein to regenerate the amine-based absorbent.

[0005] Patent Literature 2 discloses a conventional apparatus that includes a cooling unit that cools a decarbonated flue gas from which CO_2 has been absorbed and removed by gas-liquid contact with an absorbent, and a contact unit that allows condensed water obtained by condensation in the cooling unit to be brought into countercurrent contact with the decarbonated flue gas. Further, Patent Literature 2 discloses an apparatus including a water rinsing unit that allows a decarbonated flue gas, from which CO_2 has been absorbed and removed by gas-liquid contact with an absorbent, to be brought into gas-liquid contact with rising water to recover amine compounds accompanying the decarbonated flue gas. The rinsing water is condensed water obtained by condensation in a cooling tower that cools a flue gas before the recovery of CO_2.

Citation List

Patent Literature

[0006] Patent Literature 1: Japanese Laid-open Patent Publication No. 2002-126439

Patent Literature 2: Japanese Laid-open Patent Publication No. 8-80421

Summary

[0007] In recent years, however, a further reduction in the concentration of components in an absorbent that remain in and are released from a decarbonated flue gas is desired from the viewpoint of environmental preservation. In particular, when a CO_2 recovery unit is installed for a flue gas emitted from thermal power plants and the like, in which the amount of mass gas flow to be treated is expected to be large in the future, the amount of the flue gas emitted is so large that the amount of absorbent components that remain in and are released from the decarbonated flue gas is likely to be increased. Therefore, it is necessary to further reduce the concentration of basic amine compounds (absorbent components) released.

[0008] Some embodiments of the present disclosure are directed to providing a CO_2 recovery unit and a CO_2 recovery method that can further reduce the concentration of basic amine compounds which remain in and are released from a decarbonated flue gas.

[0008a] According to an aspect of the present invention, there is provided a CO_2 recovery unit comprising: a CO_2 absorber configured to bring a CO_2-containing flue gas containing CO_2 into contact with a CO_2-absorbent to remove CO_2; and a CO_2-absorbent regenerator configured to separate CO_2 from the CO_2-absorbent that has absorbed CO_2 therein and to regenerate the CO_2-absorbent; a lean solution obtained by removing CO_2 in the absorbent regenerator being reutilized in the CO_2 absorber, wherein the CO_2 absorber comprising: a CO_2-absorbing unit that absorbs CO_2 in a CO_2-containing flue gas with the CO_2-absorbent; a main water rinsing unit that is

provided on a gas flow downstream side of the CO_2-absorbing unit and that uses rinsing water to recover the accompanying CO_2-absorbent while cooling decarbonated flue gas; a circulation line that supplies the rinsing water containing the CO_2-absorbent recovered in a liquid reservoir in the main water rinsing unit from a top portion side in the main water rinsing unit, and circulates the rinsing water; and a preliminary water rinsing unit provided between the CO_2-absorbing unit and the main water rinsing unit, and the CO_2 recovery unit being configured to: withdraw a portion of the rinsing water containing the CO_2-absorbent from the main water rinsing unit, supply the portion of the rinsing water into the preliminary water rinsing unit from the main water rinsing unit side to preliminarily rinse the CO_2-absorbent that accompanies the flue gas, and recover the CO_2-absorbent; and allow the preliminary rinsing water obtained by the preliminary rinsing to meet with the CO_2-absorbent through the CO_2-absorbing unit, bring into countercurrent contact with the flue gas and directly flow down on a lower side of the CO_2-absorbing unit.

[0008b] According to another aspect of the present invention, there is provided a method for recovering CO_2, using a CO_2 absorber configured to bring a CO_2-containing flue gas containing CO_2 into contact with a CO_2-absorbent to remove CO_2, and a CO_2-absorbent regenerator configured to separate CO_2 from the CO_2-absorbent that absorbs CO_2 and to regenerate the CO_2-absorbent, a lean solution obtained by removing CO_2 in the absorbent regenerator being reutilized in the CO_2 absorber, the method comprising: supplying from a top portion side in a main water rinsing unit a rinsing water containing the CO_2-absorbent recovered in a liquid reservoir in the main water rinsing unit,

the main water rinsing unit being provided downstream of the CO_2 absorber; cooling a CO_2-removed flue gas with the rinsing water recovering the accompanied CO_2-absorbent; withdrawing a portion of the rinsing water circulating in the main water rinsing unit and supplying the portion of the rinsing water into a preliminary water rinsing unit provided between the CO_2-absorbing unit and the main water rinsing unit; subjecting the CO_2-removed flue gas after the recovery of CO_2 on a former stage side of the main water rinsing unit to preliminarily rinsing; and allowing the preliminary rinsing water used in the preliminary water rinsing to meet with the CO_2-absorbent through the CO_2-absorbing unit, bring into countercurrent contact with the flue gas, directly flow down on a lower side of the CO_2-absorbing unit and to meet with the CO_2-absorbent.

[0009] According to another aspect, there is provided a CO_2 recovery unit including: a CO_2 absorber configured to bring a CO_2-containing flue gas containing CO_2 into contact with a CO_2-absorbent to remove CO_2; and a CO_2-absorbent regenerator configured to separate CO_2 from the CO_2-absorbent that has absorbed CO_2 therein and to regenerate the CO_2-absorbent; a lean solution obtained by removing CO_2 in the absorbent regenerator being reutilized in the CO_2 absorber, wherein the CO_2 absorber including: a CO_2-absorbing unit that absorbs CO_2 in a CO_2-containing flue gas with the CO_2-absorbent; a main water rinsing unit that

is provided on a gas flow downstream side of the CO_2-absorbing unit and that uses rinsing water to recover the accompanying CO_2-absorbent while cooling decarbonated flue gas; a circulation line that supplies the rinsing water containing the CO_2-absorbent recovered in a liquid reservoir in the main water rinsing unit from a top portion side in the main water rinsing unit, and circulates the rinsing water; and a preliminary water rinsing unit provided between the CO_2-absorbing unit and the main water rinsing unit, and the CO_2 recovery unit being configured to: withdraw a portion of the rinsing water containing the CO_2-absorbent from the main water rinsing unit, supply the portion of the rinsing water into the preliminary water rinsing unit from the main water rinsing unit side to preliminarily rinse the CO_2-absorbent that contains CO_2 absorbed in the CO_2-absorbing unit and accompanies the flue gas, and recover the CO_2-absorbent; and allow the preliminary rinsing water obtained by the preliminary rinsing to directly flow down on the CO_2-absorbing unit side.

[0010] According to another aspect,

there is provided the CO_2 recovery unit according to the first aspect, further including a cooling unit that cools a portion of the withdrawn rinsing water.

[0011] According to another aspect,

there is provided the CO_2 recovery unit according to the first or second aspect, further including a finish water rinsing unit that is provided on a rear stage side of gas flow in the main water rinsing unit, for finish rinsing with the rinsing water supplied from the outside of the main water rinsing unit.

[0012] According to another aspect,

there is provided the CO_2 recovery unit

according to any one of the first to third aspects, further including a concentration unit that removes a volatile substance contained in a portion of the rinsing water withdrawn from the main water rinsing unit, wherein concentrated water from which the volatile substance has been removed is supplied, as rinsing water, into the preliminary water rinsing unit.

[0013] According to another aspect, there is provided the CO_2 recovery unit according to any one of the first to fourth aspects, wherein the main water rinsing unit is provided in a plurality of stages.

[0014] According to another aspect, there is provided a method for recovering CO_2, using a CO_2 absorber configured to bring a CO_2-containing flue gas containing CO_2 into contact with a CO_2-absorbent to remove CO_2, and a CO_2-absorbent regenerator configured to separate CO_2 from the CO_2-absorbent that absorbs CO_2 and to regenerate the CO_2-absorbent, a lean solution obtained by removing CO_2 in the absorbent regenerator being reutilized in the CO_2 absorber, the method including: cooling a CO_2-removed flue gas with rinsing water on a rear flow side of the CO_2 absorber and withdrawing a portion of rinsing water in the main water rinsing unit that recovers the accompanied CO_2-absorbent; subjecting the CO_2-removed flue gas after the recovery of CO_2 on a former stage side of the main water rinsing unit to preliminarily rinsing; and allowing the preliminary rinsing water used in the preliminary water rinsing to directly flow down on the CO_2-absorbing unit side and to meet with the CO_2-absorbent.

[0015] According to another aspect, there is provided the method for recovering CO_2 according to the sixth aspect, wherein finish rinsing is

carried out with finish rinsing water supplied from the outside of the water rinsing unit on the rear flow side of the main water rinsing unit.

[0016] According to another aspect,

there is provided the method for recovering CO_2 according to the sixth or seventh aspect, wherein a portion of the rinsing water in the main water rinsing unit is withdrawn, a volatile substance in the withdrawn rinsing water is removed from the rinsing water for concentration to give concentrated water, and the concentrated water is used as rinsing water for preliminary rinsing.

[0017] Some embodiments can further reduce the concentration of basic amine compounds of an absorbent that remain in and are released from a decarbonated flue gas, and the recovered absorbent can be reutilized.

BRIEF DESCRIPTION OF DRAWINGS

[0018] FIG. 1 is a schematic view of a CO_2 recovery unit according to a first embodiment.

FIG. 2 is a schematic view of a CO_2 recovery unit according to a second embodiment.

FIG. 3 is a schematic view of a CO_2 recovery unit according to a third embodiment.

FIG. 4 is a graph showing a comparison of the concentration of accompanying substances in an outlet gas of an absorber in Test Example 1.

FIG. 5 is a graph showing a comparison of the concentration of accompanying substances in an outlet gas of an absorber in Test Example 2.

FIG. 6 is a graph showing a comparison of the concentration of volatile substances in an outlet gas of an absorber in Test Example 3.

Description of Embodiments

[0019] Examples of embodiments of the present invention will be described in detail with reference to the accompanying drawings. However, it should be noted that the present invention is not limited to the described embodiments of the present invention and. When there is a plurality of embodiments, a combination of the embodiments is embraced in the scope of the present invention. Constituent elements in the following embodiments include those that can easily be contemplated by a person having ordinary skill in the art or those that are substantially identical to each other.

First Embodiment

[0020] A CO_2 recovery unit according to an embodiment of the present invention will be described with reference to the accompanying drawings. FIG. 1 is a schematic view of a CO_2 recovery unit in a first embodiment.

As illustrated in FIG. 1, a CO_2 recovery unit 10A in the first embodiment includes a CO_2 absorber (hereinafter referred to as "absorber") 13 that allows a CO_2-containing flue gas 11A containing CO_2 to be brought into contact with a CO_2-absorbent (a lean solution 12B) to remove CO_2, and an absorbent regenerator 14 that regenerates a CO_2-absorbent with CO_2 absorbed therein (a rich solution 12A), wherein the lean solution 12B from which CO_2 has been removed in the absorbent regenerator (hereinafter referred to as "regenerator") 14 is reutilized in the CO_2 absorber 13, wherein the CO_2 absorber 13. The CO_2 absorber 13 includes a CO_2-absorbing unit 13A for the absorption of CO_2 in a CO_2-containing flue gas with the CO_2-absorbent, a main water rinsing unit 13C that is provided on a gas flow downstream side of the CO_2-absorbing unit 13A and that uses rinsing water 20 to recover the accompanying CO_2-absorbent while cooling CO_2-removed flue gas with the rinsing water 20, a circulation line L_1 that supplies the rinsing water 20

containing the CO_2-absorbent recovered in a liquid reservoir 21 in the main water rinsing unit 13C from a top portion side in the main water rinsing unit 13C and that circulates the rinsing water, and a preliminary water rinsing unit 13B provided between the CO_2-absorbing unit 13A and the main water rinsing unit 13C. In the CO_2 recovery unit 10A, a portion 20a of the rinsing water 20 containing the CO_2-absorbent is withdrawn through the circulation line L_1, is supplied into the preliminary water rinsing unit 13B from the main water rinsing unit 13C side, and preliminarily rinses the CO_2-absorbent that contains CO_2 absorbed in the CO_2-absorbing unit 13A and accompanies the flue gas 11B, followed by the recovery of the CO_2-absorbent. The preliminary rinsing water obtained by the preliminary rinsing is allowed to meet with a CO_2-absorbent 12 while allowing the preliminary rinsing water to directly flow down on the CO_2-absorbing unit 13A side.

In the first embodiment, a portion 20a of the rinsing water 20 containing the CO_2-absorbent is withdrawn through the circulation line L_1. However, the present invention is not limited thereto, and another construction may also be adopted, in which a reservoir that stores a portion 20a of the rinsing water 20 containing the CO_2-absorbent separately through the circulation line L_1 is provided, and the portion 20a is withdrawn from the reservoir.

[0021] In the absorber 13, the CO_2-containing flue gas 11A is brought into countercurrent contact with, for example, the CO_2-absorbent 12 based on an alkanol amine, in the CO_2-absorbing unit 13A provided at the lower side of the CO_2 absorber 13. Thereby, CO_2 contained in the CO_2-containing flue gas 11A is absorbed in the CO_2-absorbent 12 by a chemical reaction ($R\text{-}NH_2 + H_2O + CO_2 \rightarrow R\text{-}NH_3HCO_3$).

As a result, a CO_2-removed flue gas 11B that is passed

through the CO_2-absorbing unit 13A and travels upward through the inside of the CO_2 absorber 13 is substantially free from CO_2.

[0022] Next, in the preliminary water rinsing unit 13B, the CO_2-removed flue gas 11B after the removal of CO_2 is brought into gas-liquid contact with a portion 20a of rinsing water 20 withdrawn from the main water rinsing unit 13C and rinsed, and rinse the CO_2-absorbent 12 accompanying the CO_2-removed flue gas 11B.

[0023] Here, the reason why the CO_2-absorbent 12 accompanies the CO_2-removed flue gas 11B will be described. The CO_2-containing gas 11A that travels upward through the inside of the CO_2-absorbing unit 13A within the absorber 13 is accompanied by water vapor in relation with a saturated vapor pressure at the temperature.

When the CO_2-removed gas containing the water vapor is brought into countercurrent contact with the CO_2-absorbent 12, a very small portion of the CO_2-absorbent 12 accompanies, as mist, a flue gas by entrainment, in relation with a saturated vapor pressure.

As a result, a very small amount of the CO_2-absorbent 12 is contained in the CO_2-removed flue gas 11B that has been passed through the CO_2-absorbing unit 13A.

In the main water rinsing unit 13C, rinsing water 20 that is condensed water is produced from water vapor that accompanies the flue gas by cooling of the CO_2-removed flue gas 11B, and the CO_2-absorbent 12 that accompanies the flue gas is dissolved, whereby a very small amount of the CO_2-absorbent 12 is contained in the rinsing water 20.

[0024] Therefore, in the first embodiment, at first in the preliminary water rinsing unit 13B, the CO_2-absorbent 12 contained in the CO_2-removed gas 11B is rinsed and removed with the preliminary rinsing water obtained by

condensing and extracting excess water in the CO_2-removed flue gas 11B through cooling in the main water rinsing unit 13C.

Alternatively, a cooling unit 23 may be provided in a withdrawal line L_2 and a portion 20a of the rinsing water 20 is cooled to a predetermined temperature (for example, 40°C or below).

[0025] Thereafter, a CO_2-removed flue gas 11C that has been passed through the preliminary water rinsing unit 13B goes upward through a chimney tray 16 towards the main water rinsing unit 13C side, and is brought into gas-liquid contact with rinsing water 20 supplied from a top side of the water rinsing unit 13C. Thereby, the CO_2-absorbent 12 that accompanies the CO_2-removed flue gas 11C is recovered through circulation rinsing.

[0026] In the main water rinsing unit 13C, the rinsing water 20 stored in the liquid reservoir 21 in the chimney tray 16 is circulated through a circulation line L_1 for circulation rinsing.

A cooling unit 22 is provided in the circulation line L_1 for cooling the water to a predetermined temperature (for example, 40°C or below).

The CO_2-absorbent 12 that accompanies the CO_2-removed flue gas 11C can be further recovered and removed by the main rinsing with the rinsing water 20 circulated.

[0027] Thereafter, a flue gas 11D from which the CO_2-absorbent 12 has been removed is discharged to the exterior through a top 13a in the CO_2 absorber 13. Numeral 73 denotes a mist eliminator that captures mist contained in the gas.

[0028] Thus, in the first embodiment, the preliminary water rinsing unit 13B and the main water rinsing unit 13C are provided, and the CO_2-absorbent 12 dissolved in the

condensed water that accompanies the CO_2-removed gases 11B and 11C is rinsed and removed in two stages. Accordingly, the CO_2-absorbent 12 that accompanies the CO_2-removed flue gases 11B and 11C can be reliably recovered and removed.

[0029] Consequently, the concentration of basic amine compounds that remain in and are released from the CO_2-absorbent-removed flue gas 11D that is to be released to the exterior can be further reduced.

[0030] The rich solution 12A with CO_2 absorbed therein is subjected to elevated pressure by a rich solvent pump 51 interposed in a rich solution supply pipe 50, is heated by the lean solution 12B regenerated in the absorbent regenerator 14 in a rich-lean solution heat exchanger 52, and is supplied towards the top side of the absorbent regenerator 14.

[0031] The rich solution 12A released from the top side of the regenerator 14 into the tower releases a major portion of CO_2 by heating with steam from the bottom of the tower. The CO_2-absorbent 12 from which a portion or a major portion of CO_2 has been released in the regenerator 14 is called "semi-lean solution." The semi-lean solution (not illustrated) turns to a lean solution 12B from which CO_2 has been substantially completely removed by the time when the semi-lean solution flows down to the bottom of the regenerator 14. The lean solution 12B is heated with a saturated steam 62 in a regeneration heater 61 interposed in a circulation line L_{20}.

[0032] On the other hand, a CO_2 gas 41 accompanied by steam that, in a regenerator 14, has diffused from the rich solution 12A and the semi-lean solution (not illustrated) is released from a top 14a of the regenerator 14.

The CO_2 gas 41 accompanied by steam is led out through a gas discharge line L_{21}, and the steam is condensed in a

condenser 42 interposed in the gas discharge line L_{21}. Condensed water 44 is separated in a separation drum 43, and a CO_2 gas 45 is released to the outside of the system, followed by separate post treatment such as compression recovery.

The condensed water 44 separated in the separation drum 43 is supplied into the top of the absorbent regenerator 14 through a condensed water circulation pump 46 interposed in a condensed water line L_{22}.

A portion (not illustrated) of the condensed water 44 may be supplied into the circulation line L_1 of the rinsing water 20 containing the CO_2-absorbent for use in the absorption of the CO_2-absorbent 12 that accompanies the CO_2-removed flue gas 11C.

[0033] The regenerated CO_2-absorbent (lean solution 12B) is sent to the CO_2 absorber 13 side with a lean solution pump 54 through a lean solution supply pipe 53, and is circulated and utilized as the CO_2-absorbent 12 through circulation. In this case, the lean solution 12B is cooled to a predetermined temperature in a cooling unit 55, and is supplied into a CO_2-absorbing unit 13A through a nozzle 56.

Thus, the CO_2-absorbent 12 are included in a closed path through which the CO_2-absorbent 12 is circulated through the CO_2 absorber 13 and the absorbent regenerator 14, and the CO_2-absorbent 12 is reutilized in the CO_2-absorbing unit 13A of the CO_2 absorber 13. If necessary, the CO_2-absorbent 12 is supplied through a supply line not illustrated. If necessary, the CO_2-absorbent 12 is regenerated with a reclaimer not illustrated.

[0034] The CO_2-containing flue gas 11A supplied into the CO_2 absorber 13 is cooled with cooling water 71 in a cooling tower 70 provided on a former stage side, and is then introduced into a CO_2 absorber 13. In some cases, a

portion of the cooling water 71 is also supplied, as rinsing water 20 for the CO_2 absorber 13, to the top 13a of the main water rinsing unit 13C, for use in rising of the CO_2-absorbent 12 that accompanies the CO_2-removed flue gas 11B. Numerals 72, 74, and 75 denote a circulation pump, a circulation line, and a cooler, respectively.

[0035] Thus, the CO_2-absorbent 12 that is utilized while circulating through the CO_2 absorber 13 and the absorbent regenerator 14 accompanies the CO_2-removed flue gas 11B. The emission of the CO_2 absorbent from the absorber 13 is prevented by, in the preliminary water rinsing unit 13B and the main water rinsing unit 13C, absorbing and removing the CO_2-absorbent 12 accompanying the CO_2-removed flue gases 11B and 11C with the rinsing water 20 through countercurrent contact between the CO_2-removed flue gases 11B and 11C and CO_2 removed therefrom and the rinsing water 20.

[0036] As described above, in the first embodiment, in addition to the conventional main water rinsing unit 13C using a circulation rinsing water, the preliminary water rinsing unit 13B is provided. Thus, the effect of recovering the CO_2-absorbent that accompanies the CO_2-removed flue gases 11B and 11C can be improved.

Specifically, in the main water rinsing unit 13C, circulation rinsing is carried out with the circulated rinsing water 20, and, at the same time, a portion 20a of the rinsing water 20 after use in the rinsing is withdrawn through a withdrawal line L_2 and is supplied into the preliminary water rinsing unit 13B. Thus, the portion 20a of the withdrawn rinsing water 20 has a low CO_2-absorbent concentration (for example, a few percent). Consequently, a high quality of rinsing in the preliminary water rinsing unit 13B is carried out.

[0037] Specifically, when only the main water rinsing unit 13C through which the rinsing water 20 is circulated is installed in a plurality of stages within the CO_2 absorber 13, a plurality of the circulation lines, the circulation pumps, and the chimney trays 16 in which the rinsing water is stored needs to be provided, resulting in increased installation and running cost.

[0038] By contrast, the preliminary water rinsing unit 13B uses an excess portion of the rinsing water 20 used in the main water rinsing unit 13C, and what is required in the supply amount is only to be regulated with a regulation valve 24. Thus, the preliminary water rinsing unit 13B may have a simple construction.

This is so because, in the main water rinsing unit 13C, the CO_2-removed flue gas 11C is cooled with the rinsing water 20 and gaseous water that accompanies the CO_2-removed flue gas 11C is condensed and becomes excess water, making it possible to use the excess portion in preliminary rinsing.

[0039] A chimney tray 16 that is a partition member is not provided between the preliminary water rinsing unit 13B and the CO_2-absorbing unit 13A. Thus, a portion 20a of the rinsing water after use in the preliminary rinsing directly meets with the CO_2-absorbent (lean solution 12A).

As a result, the preliminary rinsing water that has been used in the preliminary rinsing for the recovery of the CO_2-absorbent contains the CO_2-absorbent in a somewhat larger amount than a portion 20a of the rinsing water withdrawn through the circulation line L_1, contributing to the recovery of CO_2 in the CO_2-absorbing unit 13A.

Specifically, for example, the lean solution 12B of the CO_2-absorbent in the concentration of 30% meets with the rinsing water 20a containing the CO_2-absorbent in the

concentration of a few percent + α.

As a result, as compared to the case where the condensed water recovered in the rinsing unit is supplied to a bottom 13b side of the CO_2 absorber 13 in the prior art, the concentration is higher by a value corresponding to the recovery of the CO_2-absorbent in the preliminary water rinsing unit 13B, leading to an improvement in the effect of removing CO_2 contained in the CO_2-containing flue gas 11A in the CO_2-absorbing unit 13A.

Second Embodiment

[0040] A CO_2 recovery unit in another embodiment of the present invention will be described with reference to the accompanying drawings. FIG. 2 is a schematic view of a CO_2 recovery unit according to a second embodiment. The components same as those in the CO_2 recovery unit 10A in the first embodiment illustrated in FIG. 1 are denoted by the same reference characters, and the description thereof will not be repeated.

As illustrated in FIG. 2, in a CO_2 recovery unit 10B in the second embodiment, a finish water rinsing unit 13D is further provided on a gas flow rear stage side of a main water rinsing unit 13C in the CO_2 recovery unit 10A illustrated in FIG. 1 and performs finish rinsing with rinsing water 20 supplied from the exterior of the main water rinsing unit 13C. In the second embodiment, a portion 44a of the condensed water 44 separated from a CO_2 gas 41 accompanied by steam released to the exterior is supplied through a branched line L_{23} from the top 14a of a regenerator 14 and is used as rinsing water in the finish water rinsing unit 13D.

A cooling unit 25 may be provided in the branched line L_{23} and a portion 44a of the condensed water 44 may be cooled to a predetermined temperature (for example, 40°C or

below).

[0041] A portion 44a of the condensed water 44 is in a state separated from the CO_2 gas 41 accompanied by the steam released to the exterior from the regenerator 14. Accordingly, the condensed water 44 is substantially free from CO_2-absorbent, and, thus, high finish rinsing efficiency can be realized.

Alternatively, in addition to the portion 44a of the condensed water 44, ion exchanged water may be separately supplied as the finish rinsing water in the finish water rinsing unit 13D.

[0042] Thus, in the second embodiment, the concentration of the CO_2-absorbent diffused to the exterior from the top 13a of the absorber 13 can be further reduced by using, as a finish rinsing water, a liquid containing a gas accompanying substance such as the CO_2-absorbent at a low concentration, and bringing the finish rinsing water into gas-liquid contact with the CO_2-absorbent-removed flue gas 11D on the rearmost flow side (top 13a side) of the final stage in the water rinsing unit.

[0043] As a result, the concentration of basic amine compounds that remain in and are released from a CO_2-removed flue gas 11E released to the exterior can be further reduced as compared to the concentration of basic amine compounds in the first embodiment.

Third Embodiment

[0044] A CO_2 recovery unit in a third embodiment of the present invention will be described with reference to the accompanying drawings. FIG. 3 is a schematic view of a CO_2 recovery unit according to the third embodiment. The same components as those in the CO_2 recovery unit 10A in the first embodiment illustrated in FIG. 1 are denoted by the same reference characters, and the description thereof

will not be repeated.

As illustrated in FIG. 3, a CO_2 recovery unit 10C in the second embodiment has the same construction as that of the CO_2 recovery unit 10A illustrated in FIG. 1, except that the following elements are additionally provided: a withdrawal line L_2 that withdraws, as a withdrawn water, a portion 20a of rinsing water 20 containing a CO_2-absorbent 12 from the circulation line L_1 for the rinsing liquid 20 that is circulated through a main water rinsing unit 13C; a gas-liquid separator 30A that separates a gas component 32 from withdrawn liquid; a concentration tower 30B that concentrates the CO_2-absorbent 12 in the withdrawn liquid 20a to separate the gas component 32; an introduction line L_3 that introduces, as preliminary rinsing water, a concentrated solution 33 obtained by concentrating the CO_2-absorbent 12 into a preliminary water rinsing unit 13B; and a gas introduction line L_4 that introduces the separated gas component 32 into a top 13a side of an absorber 13. In the third embodiment, the gas-liquid separator 30A and a concentration tower 30B are included in a concentration unit.

[0045] In the gas-liquid separator 30A, the withdrawn liquid is at first diffused to separate liquid 31 from the gas component 32, and thus, the gas component 32 is separated from the withdrawn liquid.

The gas component 32 is a highly volatile substance such as ammonia contained in the CO_2-absorbent 12 and is discharged to the gas introduction line L_4.

[0046] The liquid 31 from which the gas component 32 has been separated in the gas-liquid separator 30A is introduced into the concentration tower 30B.

[0047] Air 35 is blown into the concentration tower 30B, and the gas component 32 remaining in the liquid 31 is further withdrawn.

If necessary, a line (not illustrated) that recovers volatile substances in a liquid phase and discharges the recovered liquid phase is provided in the concentration tower 30B.

Consequently, volatile substances, for example, ammonia, can be removed from the liquid 31 to give the concentrated solution 33.

In the third embodiment, the concentrated solution 33 from which ammonia or the like has been removed is supplied through the supply line L_3 towards the preliminary water rinsing unit 13B side and is used as preliminary rinsing water.

[0048] Thus, a concentration unit 30 is provided in a withdrawal line L_2 in the main water rinsing unit 13C to give the concentrated solution 33 obtained by separating steam-containing volatile substances from the rinsing liquid. Further, since the concentrated solution 33 free from volatile substances is used as the preliminary rinsing water, volatile components such as ammonia can be absorbed and removed with the preliminary rinsing water. Consequently, the concentration of volatile accompanying substance components in the CO_2-removed flue gas 11C introduced into the main water rinsing unit 13C can be reduced.

[0049] As a result, the concentrations of basic amine compounds and volatile substances that remain in and are released from the CO_2-absorbent-removed flue gas 11D released to the exterior can be further reduced as compared to that in the first embodiment.

[0050]

[Test Example 1]

A test that examines the effect of the first embodiment of the present invention was carried out.

Specifically, a flue gas containing 14% of carbon dioxide was supplied at 200 Nm^3/hr into the CO_2-absorbing unit 13A in the absorber 13, and was brought into countercurrent contact with a basic amine solution (CO_2-absorbent) to absorb carbon dioxide.

In this Test Example, a preliminary water rinsing unit 13B was provided on a rear flow (upper portion) side of the CO_2-absorbing unit 13A.

An excess portion of the rinsing water in the main water rinsing unit 13C was withdrawn for use as the rinsing water in the preliminary water rinsing unit 13B and was brought into countercurrent contact with the flue gas to directly flow down to the CO_2-absorbent. In the main water rinsing unit 13C, the rinsing water was brought into countercurrent contact with the gas at a liquid/gas ratio of 4 L/Nm^3, and the gas was passed through a demister 73 disposed at the outlet.

The results are shown in FIG. 4. FIG. 4 is a graph illustrating a comparison of the concentration of accompanying substances in outlet gas from the absorber in Test Example 1. In FIG. 4, the left graph illustrates results of a conventional method in which the preliminary water rinsing unit is not provided, and the right graph illustrates a method in which the preliminary water rinsing unit is provided.

When the preliminary water rinsing unit was provided as in Test Example 1, the concentration ratio of accompanying substances in the outlet gas from the absorber (CO_2-absorbent-removed flue gas 11D) was reduced to 1/10.

[0051]

[Test Example 2]

A test that examines the effect of the second embodiment of the present invention was carried out.

Specifically, a flue gas containing 14% of carbon dioxide was supplied at 200 Nm^3/hr into the CO_2-absorbing unit 13A in the absorber 13, and was brought into countercurrent contact with a basic amine solution (CO_2-absorbent) to absorb carbon dioxide.

In the Test Example, a preliminary water rinsing unit 13B was provided on a rear flow (upper portion) side of the CO_2-absorbing unit 13A, and a finish water rinsing unit 13D was further provided on a rear flow (upper portion) side of the main water rinsing unit 13C.

An excess portion of the rinsing water in the main water rinsing unit 13C was withdrawn for use as the rinsing water in the preliminary water rinsing unit 13B, and was brought into countercurrent contact with the flue gas to directly flow down to the CO_2-absorbent 12. The rinsing water was then brought into countercurrent contact with the gas at a liquid/gas ratio of 4 L/Nm^3. In the finish water rinsing unit 13D, a portion of reflux water in the regenerator was introduced and was brought into countercurrent contact with the gas to directly flow down to the rinsing liquid in the main water rinsing unit 13C. The gas was then passed through a demister 73 disposed at the outlet.

The results are shown in FIG. 5. FIG. 5 is a graph illustrating a comparison of the concentration of accompanying substances in outlet gas from the absorber in Test Example 2. In FIG. 5, the left graph illustrates the results of Test Example 1 where the preliminary water rinsing unit was provided while the finish water rinsing unit was not provided. The right graph illustrates a method in which the preliminary water rinsing unit and the finish water rinsing unit were provided before and after the main water rinsing unit.

When the preliminary water rinsing unit and the finish water rinsing unit were provided before and after the main water rinsing unit as in Test Example 2, the concentration ratio of accompanying substances in outlet gas from the absorber (CO_2-absorbent-removed flue gas 11E) was reduced to 1/10. Thus, the concentration ratio was reduced to 1/100, as compared to that in the conventional method in Test Example 1 (preliminary water rinsing unit and finish water rinsing unit are not provided).

[0052] [Test Example 3]

A test that examines the effect of the third embodiment of the present invention was carried out.

Specifically, a flue gas containing 14% of carbon dioxide was supplied at 200 Nm^3/hr into the CO_2-absorbing unit 13A in the absorber 13, and was brought into countercurrent contact with a basic amine solution (CO_2-absorbent) to absorb carbon dioxide.

In this Test Example, a preliminary water rinsing unit 13B was provided on a rear flow (upper portion) side of the CO_2-absorbing unit 13A, and a concentration unit 30 was further provided on the withdrawal line L_2 in the main water rinsing unit 13C.

An excess portion of the rinsing water in the main water rinsing unit 13C was withdrawn for use as the rinsing water in the preliminary water rinsing unit 13B, and was brought into countercurrent contact with a flue gas to directly flow down to the CO_2-absorbent. The rinsing water was then brought into countercurrent contact with the gas at a liquid/gas ratio of 4 L/Nm^3 in the main water rinsing unit 13C, and the gas was passed through a demister 73 disposed at the outlet.

The results are shown in FIG. 6. FIG. 6 is a graph illustrating a comparison of the concentration of volatile

substances in outlet gas from the absorber in Test Example 3. In FIG. 6, the left graph illustrates the results of Test Example 1 where the concentration unit was not provided, and the right graph illustrates a method in which the concentration unit was provided.

When the concentration unit was provided as in Test Example 3, the concentration ratio of volatile accompanying substances in outlet gas from the absorber (CO_2-absorbent-removed flue gas 11D) was reduced to 2/5.

Reference Signs List

[0053] 10A to 10C CO_2 recovery unit

11A CO_2-containing gas

12 CO_2-absorbent

12A Rich solution

12B Lean solution

13 CO_2 absorber (absorber)

13A CO_2-absorbing unit

13B Preliminary water rinsing unit

13C Main water rinsing unit

13D Finish water rinsing unit

14 Absorbent regenerator (regenerator)

20 Rinsing water

20a Portion of rinsing water

CLAIMS:

1. A CO_2 recovery unit comprising:

a CO_2 absorber configured to bring a CO_2-containing flue gas containing CO_2 into contact with a CO_2-absorbent to remove CO_2; and

a CO_2-absorbent regenerator configured to separate CO_2 from the CO_2-absorbent that has absorbed CO_2 therein and to regenerate the CO_2-absorbent;

a lean solution obtained by removing CO_2 in the absorbent regenerator being reutilized in the CO_2 absorber, wherein

the CO_2 absorber comprising:

a CO_2-absorbing unit that absorbs CO_2 in a CO_2-containing flue gas with the CO_2-absorbent;

a main water rinsing unit that is provided on a gas flow downstream side of the CO_2-absorbing unit and that uses rinsing water to recover the accompanying CO_2-absorbent while cooling decarbonated flue gas;

a circulation line that supplies the rinsing water containing the CO_2-absorbent recovered in a liquid reservoir in the main water rinsing unit from a top portion side in the main water rinsing unit, and circulates the rinsing water; and

a preliminary water rinsing unit provided between the CO_2-absorbing unit and the main water rinsing unit, and

the CO_2 recovery unit being configured to:

withdraw a portion of the rinsing water containing the CO_2-absorbent from the main water rinsing unit, supply the portion of the rinsing water into the preliminary water rinsing unit from the main water rinsing unit side to preliminarily rinse the CO_2-absorbent that accompanies the flue gas, and recover the CO_2-absorbent; and

allow the preliminary rinsing water obtained by the preliminary rinsing to meet with the CO_2-absorbent through the CO_2-absorbing unit, bring into countercurrent contact with the flue gas and directly flow down on a lower side of the CO_2-absorbing unit.

2. The CO_2 recovery unit according to claim 1, further comprising a cooling unit that cools the portion of the withdrawn rinsing water.

3. The CO_2 recovery unit according to claim 1 or 2, further comprising a finish water rinsing unit that is provided on a rear stage side of gas flow in the main water rinsing unit, for finish rinsing with the rinsing water supplied from the outside of the main water rinsing unit.

4. The CO_2 recovery unit according to any one of claims 1 to 3, further comprising a concentration unit that removes a volatile substance contained in the portion of the rinsing water withdrawn from the main water rinsing unit,

wherein concentrated water from which the volatile substance has been removed is supplied, as rinsing water, into the preliminary water rinsing unit.

5. The CO_2 recovery unit according to any one of claims 1 to 4, wherein the main water rinsing unit is provided in a plurality of stages.

6. A method for recovering CO_2, using a CO_2 absorber configured to bring a CO_2-containing flue gas containing CO_2 into contact with a CO_2-absorbent to remove CO_2, and a CO_2-absorbent regenerator configured to separate CO_2 from the CO_2-absorbent that absorbs CO_2 and to regenerate the CO_2-absorbent, a lean solution obtained by removing CO_2 in the absorbent regenerator being reutilized in the CO_2 absorber, the method comprising:

supplying from a top portion side in a main water rinsing unit a rinsing water containing the CO_2-absorbent recovered in a liquid reservoir in the main water rinsing unit, the main water rinsing unit being provided downstream of the CO_2 absorber;

cooling a CO_2-removed flue gas with the rinsing water recovering the accompanied CO_2-absorbent;

withdrawing a portion of the rinsing water circulating in the main water rinsing unit and supplying the portion of the rinsing water into a preliminary water rinsing unit provided between the CO_2-absorbing unit and the main water rinsing unit;

subjecting the CO_2-removed flue gas after the recovery of CO_2 on a former stage side of the main water rinsing unit to preliminarily rinsing; and

allowing the preliminary rinsing water used in the preliminary water rinsing to meet with the CO_2-absorbent through the CO_2-absorbing unit, bring into countercurrent contact with the flue gas, directly flow down on a lower side of the CO_2-absorbing unit and to meet with the CO_2-absorbent.

7. The method for recovering CO_2 according to claim 6, wherein finish rinsing is carried out with finish rinsing water supplied from the outside of the water rinsing unit on the rear flow side of the main water rinsing unit.

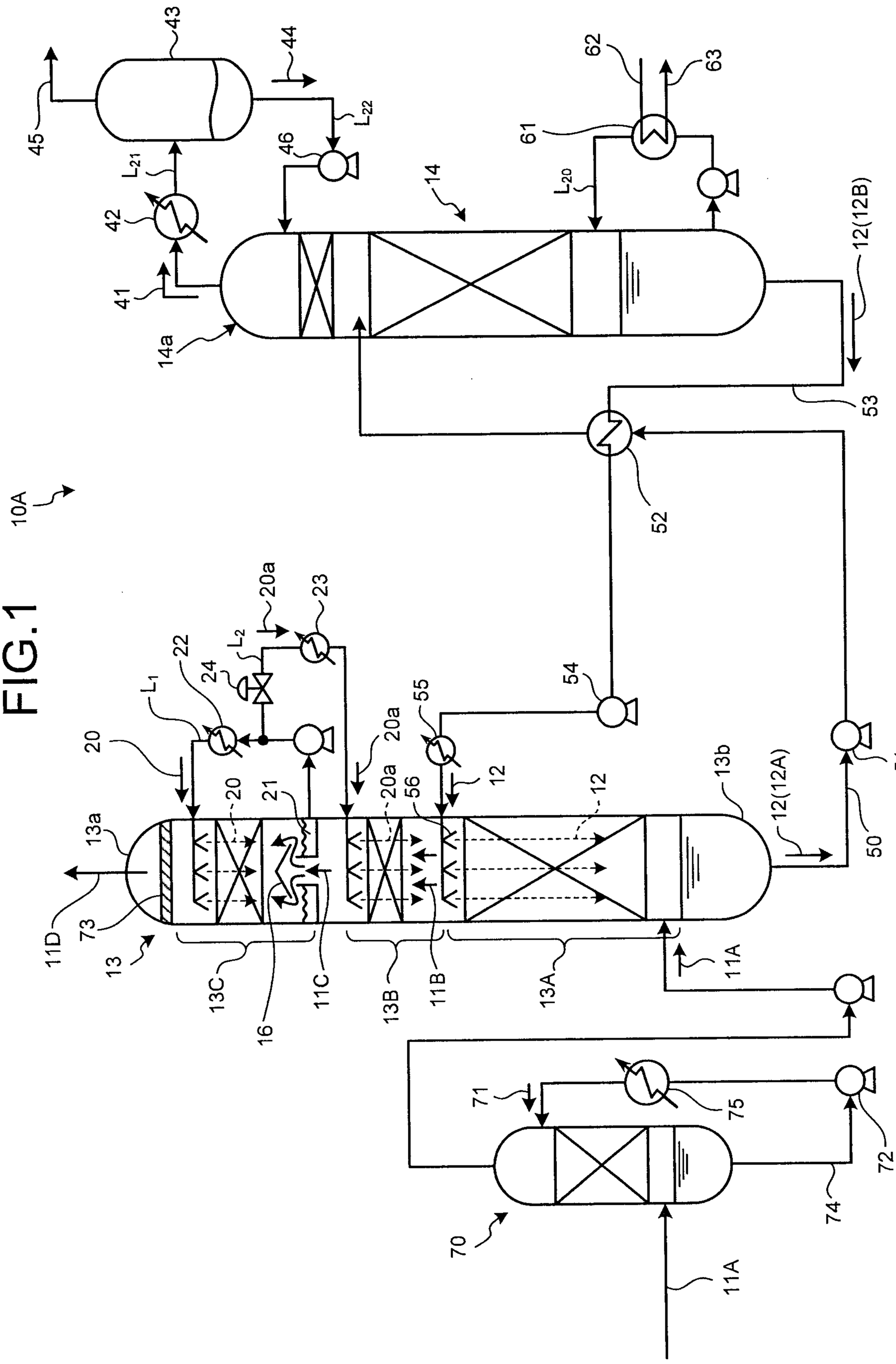
8. The method for recovering CO_2 according to claim 6 or 7, wherein

a portion of the rinsing water the main water rinsing unit is withdrawn,

a volatile substance in the withdrawn rinsing water is removed from the rinsing water for concentration to give concentrated water, and

the concentrated water is used as rinsing water for preliminary rinsing.

FIG.1


10A
11D
73
13a
13
13C
16
11C
13B
11B
13A
11A
13b
12(12A)
50
51
53
52
54
55
56
12
12(12B)
14
14a
41
42
43
44
45
46
L_{21}
L_{22}
L_{20}
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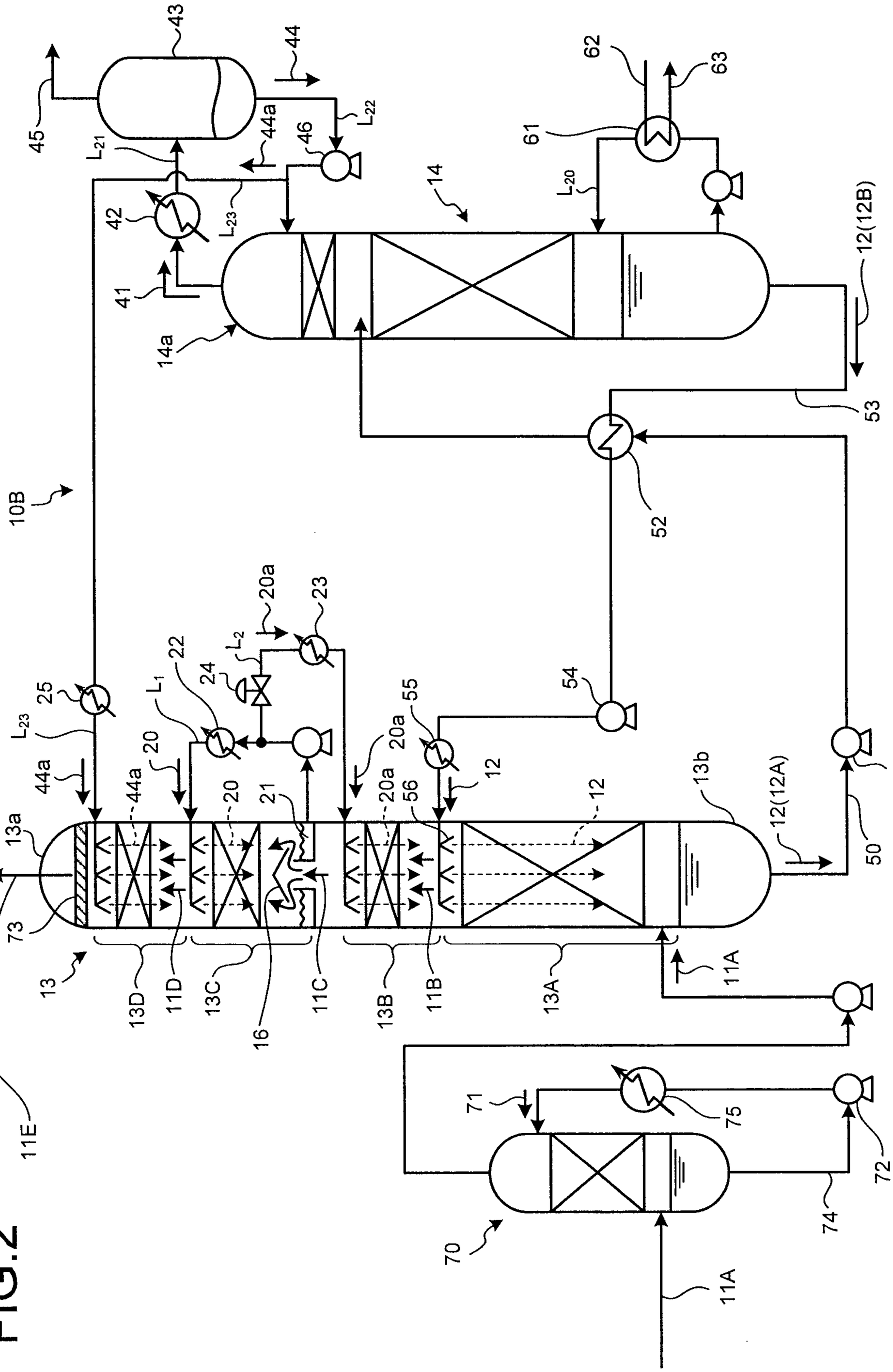
21
22
24
L_1
L_2
23
61
62
63
71
72
74
75
70


10B
11E
43
44
45
44a
46
L_{22}
L_{21}
42
L_{23}
41
14a
14
62
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61
L_{20}
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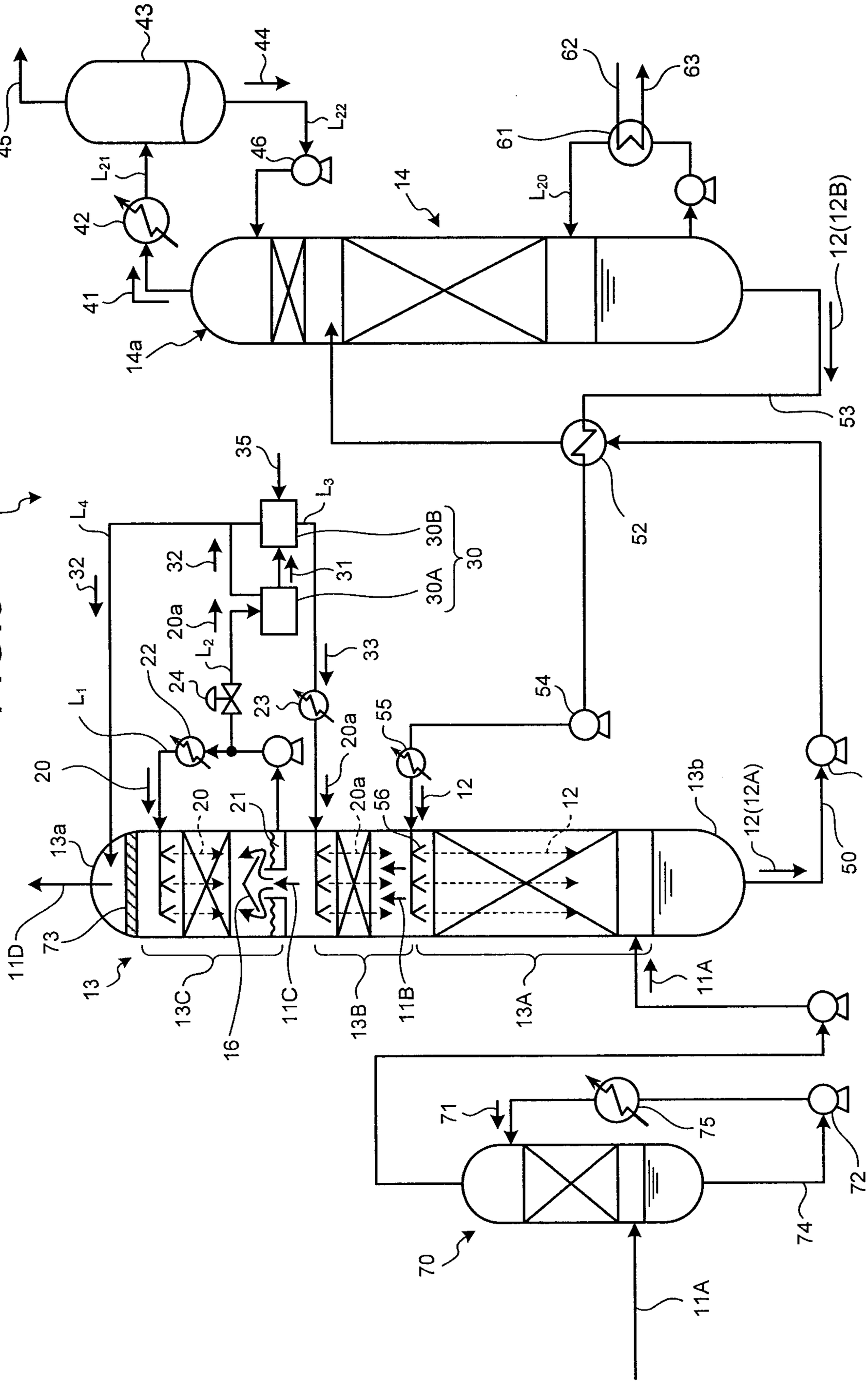
53
52
L_2
20a
23
L_1
22
24
25
20
21
54
55
56
12
13a
73
16
13
13D
11D
13C
11C
13B
11B
13A
13b
12(12A)
50
51
11A
71
75
72
74
70

FIG.2

FIG.3


10C
43
44
45
L_{22}
46
L_{21}
42
41
14a
14
62
63
61
L_{20}
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L_3
L_4
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30B
30A
30
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L_2
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23
33
L_1
20
21
54
55
56
12
13a
13b
12(12A)
51
50
11D
73
13
13C
16
11C
13B
11B
13A
11A
71
75
72
74
70

FIG.4

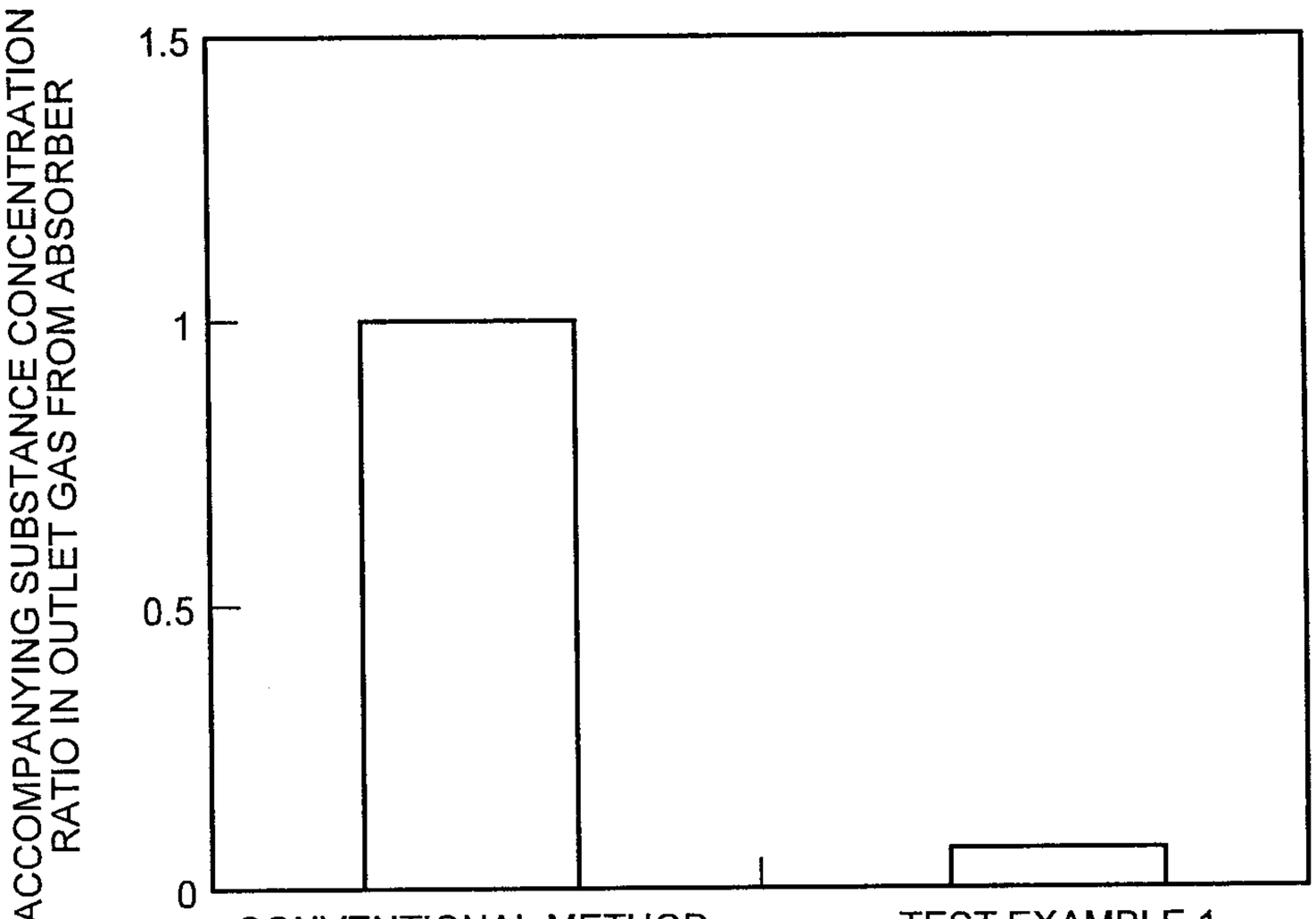

ACCOMPANYING SUBSTANCE CONCENTRATION RATIO IN OUTLET GAS FROM ABSORBER
1.5
1
0.5
0
CONVENTIONAL METHOD (PRELIMINARY WATER RINSING UNIT NOT PROVIDED)
TEST EXAMPLE 1 (PRELIMINARY WATER RINSING UNIT PROVIDED)

FIG.5

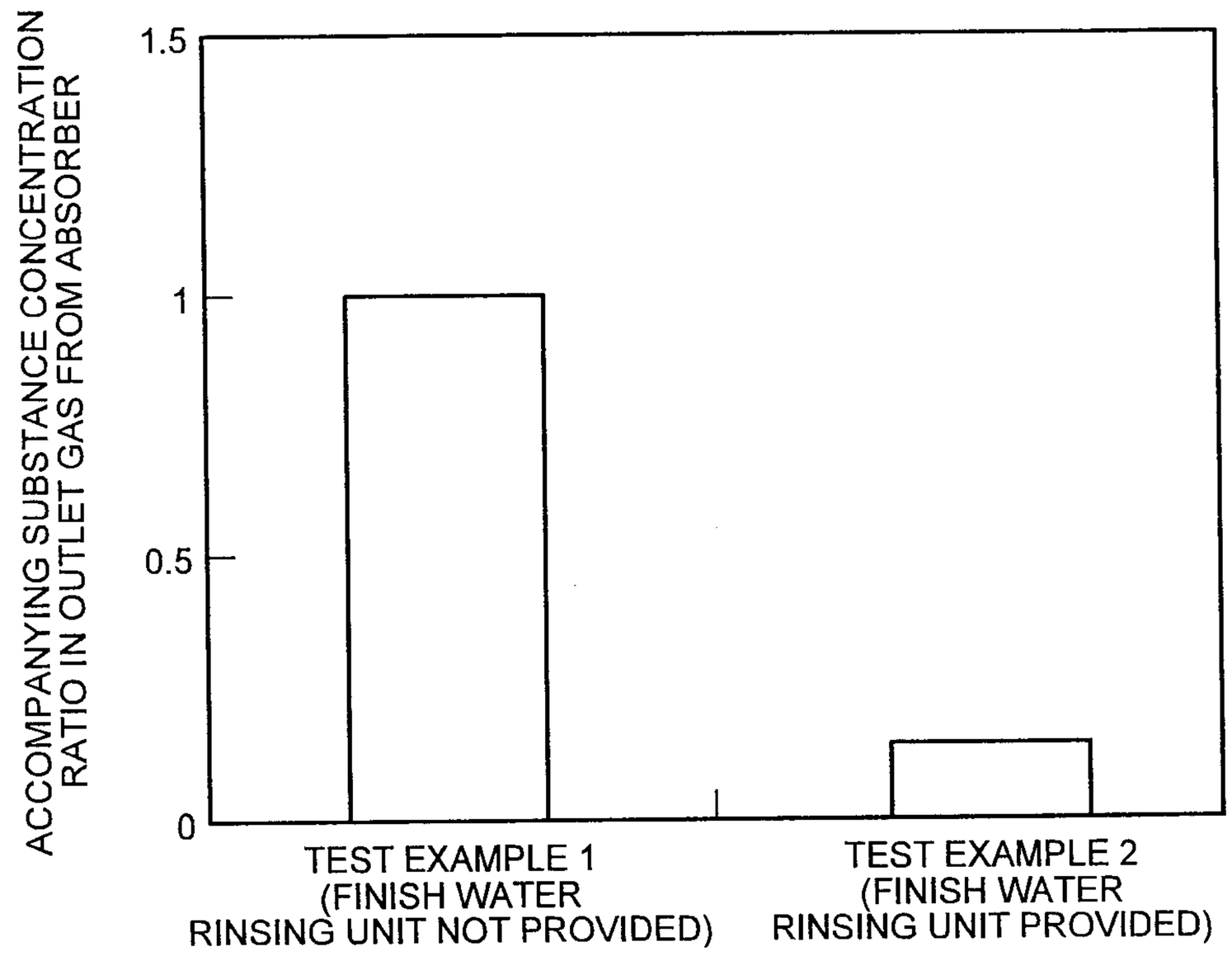
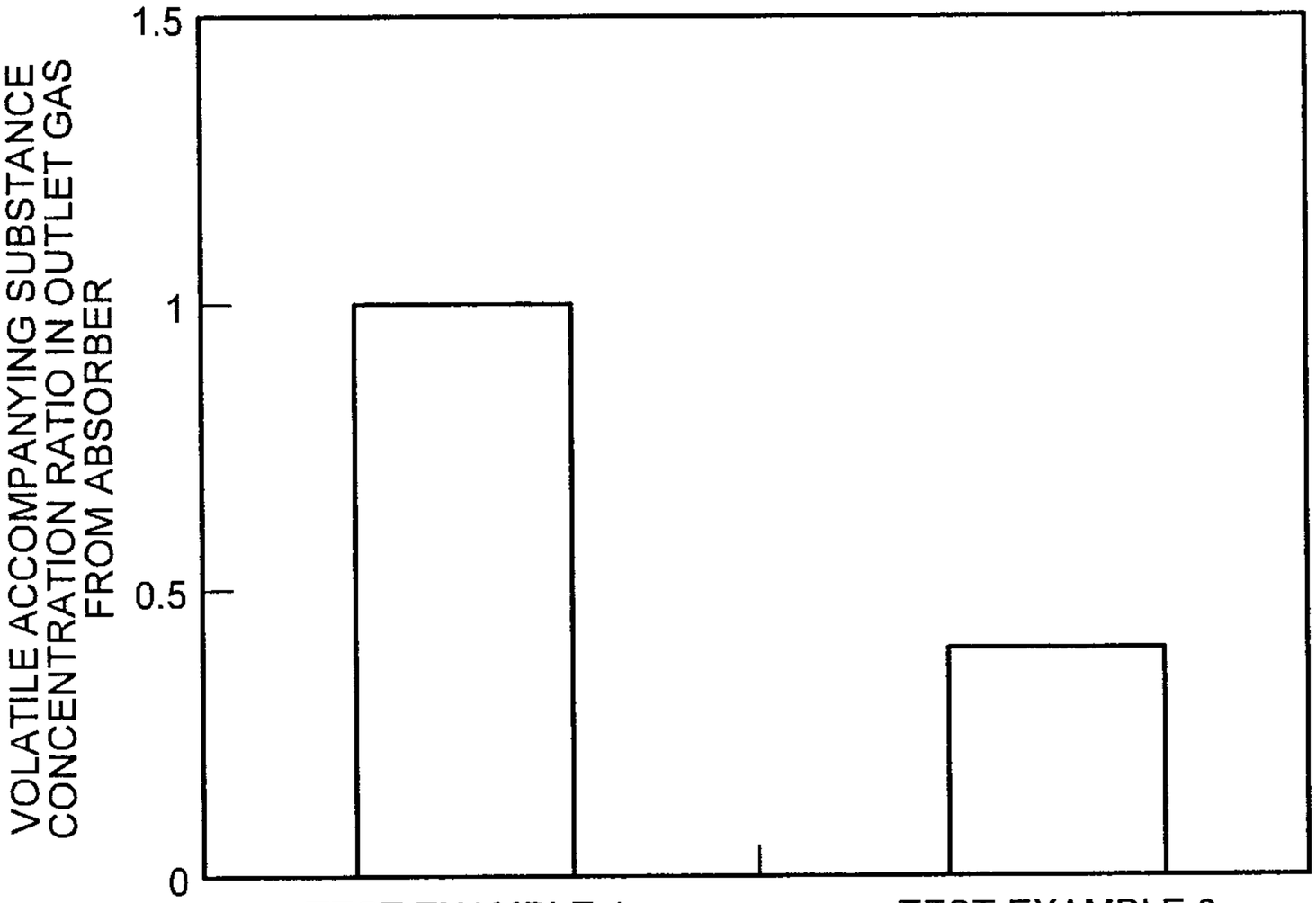
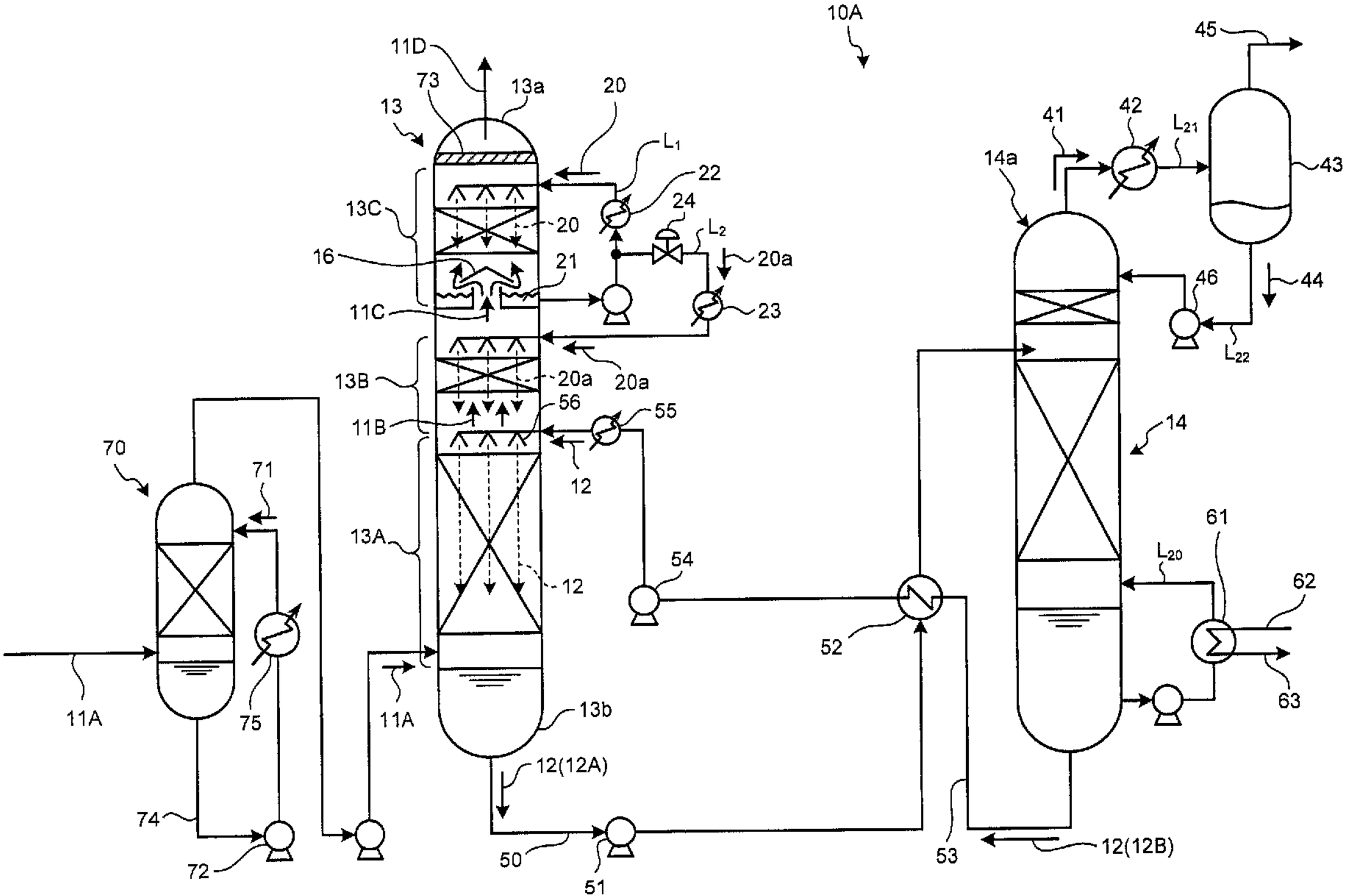

ACCOMPANYING SUBSTANCE CONCENTRATION RATIO IN OUTLET GAS FROM ABSORBER
1.5
1
0.5
0
TEST EXAMPLE 1 (FINISH WATER RINSING UNIT NOT PROVIDED)
TEST EXAMPLE 2 (FINISH WATER RINSING UNIT PROVIDED)

FIG.6


VOLATILE ACCOMPANYING SUBSTANCE CONCENTRATION RATIO IN OUTLET GAS FROM ABSORBER
1.5
1
0.5
0
TEST EXAMPLE 1 (CONCENTRATION UNIT NOT PROVIDED)
TEST EXAMPLE 3 (CONCENTRATION UNIT PROVIDED)


10A
11D
73
13a
20
13
L1
22
24
L2
20a
13C
20
16
21
11C
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13B
20a
20a
56
55
11B
12
70
71
13A
12
54
52
11A
75
11A
13b
12(12A)
74
72
50
51
53
12(12B)
45
41
42
L21
14a
43
46
44
L22
14
61
L20
62
63